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# EFFECTIVENESS OF THE POROUS VENEER INTAKE IN EXCLUDING FISH AT DARLINGTON - SONAR EVALUATIONS YEAR 1 1990

Report No 91-36-K

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## ABSTRACT

Investigations were conducted on the use of sonar coupled with impingement records in determining the effectiveness of the Darlington porous veneer in excluding fish. Continuous acoustic sampling was conducted June 12-14, July 23-25, and October 16-17 to assess the number of fish encounters and fish behaviour above both porous and non-porous sections of the veneer. Under minimal flow conditions (one unit operating), few fish were impinged relative to the number of fish echo encounters. This was especially evident in July where large numbers of alewife were observed above the intake. A comparison between sonar and netting techniques for assessing fish encounters and fish behaviour was made. Remote transmission of data from the field to the laboratory as a cost-effective means of collecting and analyzing data was also demonstrated. Future research is proposed to determine effectiveness of the veneer when two or more units at Darlington are operating.



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EXECUTIVE SUMMARY

# EFFECTIVENESS OF THE POROUS VENEER INTAKE IN EXCLUDING FISH AT DARLINGTON - SONAR EVALUATIONS YEAR 1 1990

P.H. Patrick

The Darlington porous veneer intake has been designed to reduce fish entrapment. Although research conducted in the laboratory has indicated a high effectiveness it has not yet been field evaluated. The primary objective of this study is to field evaluate the effectiveness of the veneer in excluding fish by using sonar and fish impingement data. Other objectives of this study are (1) to compare the sonar results with standard gill netting practices in estimating fish abundance, distribution and behaviour at Darlington, and (2) to demonstrate remote data transmission from the field to the laboratory for future assessments.

Acoustic sampling was conducted June 12-14, July 23-25, and October 16-17 to assess the number of fish encounters and fish behaviour in the vicinity of the veneer. Continuously recorded sonar data were collected during both day and night periods using four transducer multiplexed at regular intervals covering both porous and non-porous sections. Paired gill nets were also set to the east and west of the veneer.

Few fish were impinged during each sampling period. The number of fish encounters based on sonar data was highest in July followed by June and October. The gill net data showed the same trend. The principle species collected was alewife. Several thousand fish echoes were noted in July yet impingement was negligible suggesting high effectiveness. Similarly, in June and October, when fish numbers were lower, there were few fish impinged relative to the number of encounters. Still, these results are preliminary since intake flows were low averaging less than 50 m3/s for each sampling period (ie. one unit operation). Future research will be required to determine if this trend will continue under high flow regimes. Two units are expected to be operating in 1991.



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There was also no evidence of fish preference or attraction to the porous sections of the veneer relative to the non-porous ones. This was found to be consistent for both June and July dates. Intake flows were however, minimal. Further research will be required to determine if this trend continues under higher intake flow rates.

Some limited information of the vertical distribution of fish echoes was collected on July 25 (21:45-22:30). Fish echoes were divided into three approximate depth categories: surface to mid depth (2-5 m), mid depth (5-8 m) and mid depth to bottom intervals (8-11 m). Results indicated that echo distribution was relatively uniform throughout the water column.

A comparison between the sonar and gill net data indicated high temporal and spatial variabilities in abundance estimates using both techniques. Significant differences in echo counts observed for both day and night periods were attributed to both offshore-onshore movement and/or diurnal behaviour of fish.

During the July sampling period, the feasibility of remote data transmission was demonstrated as a potential cost saving measure. Transmission using modems occurred from the boat (at Darlington NGS) to both Head Office (ES&A) and Research. Automatic data collection and remote transmission are obvious advantages of sonar over other systems since they are intended to collect continuous data cost-effectively. Further studies are planned which will allow more continuous data transmission by using a sonar buoy.

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**EFFECTIVENESS OF THE POROUS VENEER INTAKE IN EXCLUDING FISH AT DARLINGTON - SONAR EVALUATIONS YEAR 1 1990**

## 1.0 INTRODUCTION

The Darlington porous veneer intake has been designed to reduce fish entrapment (Christie 1981). Research conducted in the laboratory has indicated a capture/encounter ratio less than 5% for alewife and approximately 46% for yellow perch (OHRDR 83-351-K). Field evaluation of the veneer has not yet occurred. Impingement data alone, which is routinely collected by station personnel, cannot accurately assess the performance of the veneer. For instance, low capture or impingement does not necessary mean high performance if few fish are in the immediate vicinity of the intake. Information on the number of fish encounters of the veneer relative to the number impinged are critical for assessing effectiveness. Information on fish behaviour in response to the veneer is also important, particularly if a one section of the veneer is preferred over another. Minor design modifications may be necessary. The use of sonar has been proposed as a non-consumptive technique to determine the number of fish encounters and fish behaviour in the vicinity of the intake.

Although Ontario Hydro has always had interest in the use of sonar (hydroacoustics) for obtaining fisheries data (Christie 1981), recent advancements in the technology have shown it to be more applicable than ever before (Burczynski and Johnson 1986, Rose and Leggett 1988, Thorne 1988). Sonar advancements have been made in the areas of developing real time data collection and analysis systems (Dickie et al. 1983, Brooks and Torkelson 1987, Mitchell et al. 1987, Dawson et al. 1989). Another significant contribution has been the development of the dual beam (Traynor and Ehrenberg 1979) and split beam (Foote and Traynor 1988) systems which allow for off-axis correction of target strengths.

Since 1988, the Research Division has been involved in developing sonar as a cost effective means of collecting environmental data. Modifications to present sonar coupled with artificial intelligence systems has improved the ability of present day sonar systems to detect and speciate (classify) fish (OHRDR Nos 88-260-H, 89-21-H, 89-216-H, Patrick et al. 1991, Ramani et al. 1990). For example, results have indicated an improved resolution to approximately 7 cm using a 0.1 ms pulse (420 kHz).

At the request of ES&A (Pope to Patrick, February 2, 1990, Rowsell to Glass, February 5, 1990), a proposal was prepared using sonar in conjunction with gill netting and impingement records as a method to determine the effectiveness of the veneer in excluding fish. The primary objective of sonar is to be able to estimate the numbers, behaviour and distribution of fish species encountering different parts of the veneer intake. These data will be compared to station impingement data. Secondary objectives of this study are (1) to make a preliminary comparison between the sonar results and standard gill netting practices in estimating fish abundance, distribution and behaviour at Darlington, and (2) to demonstrate remote data transmission from the field to the laboratory for future assessments.

## 2.0 MATERIALS AND METHODS

### 2.1 High Frequency Sonar

#### 2.1.1 Sonar Equipment

High frequency acoustic sampling was conducted using the following equipment: four 420 kHz transducer (Biosonics, single and dual beam, 6 and 15 degree beams), sounder (Biosonics 101), multiplexer (MUX), transducer rotator (Biosonics RC), wideband sonar detection module (WSDM), digital audio tape recorders (Sony DTC 1000), gigabyte storage recorder (Cy-Tos), oscilloscope (Philips PM 3302), cellular phones (Northern Telecom) and modems (US Robotics). The laboratory components included a plotter (Hewlett-Packard 7046 A), dual beam processor (Biosonics ESP 181), PC computer (AT 236 40 MB) printer (Epson FX), visicorder (Honeywell) and Neural Network System (SAIC). A block diagram of both laboratory and field components is shown in Figure 1.

#### 2.1.2 Sampling Locations and Periods

Acoustic sampling was conducted in the vicinity of the veneer intake as shown in Figure 2. Four transducers (three 6 degree beams, one dual 6 and 15 degree beam) were positioned on a tower on top of the veneer cap (at approximately 7-8 m depth), and were aimed horizontally to cover both porous and non-porous surface sections of the veneer (Figure 2). The depth location of these transducers allowed an assessment of fish encounters within approximately a 5 m zone above the intake surface (at 40-50 m the 6 degree cone of each transducer has a radius of approximately 2.3 m). The sampling volume of the sonar was estimated to be less than 3 % of the entire intake cap (area of 5,838 m2 by 5 m depth). Underwater photographs of the transducer arrangement is shown in Plate 1.

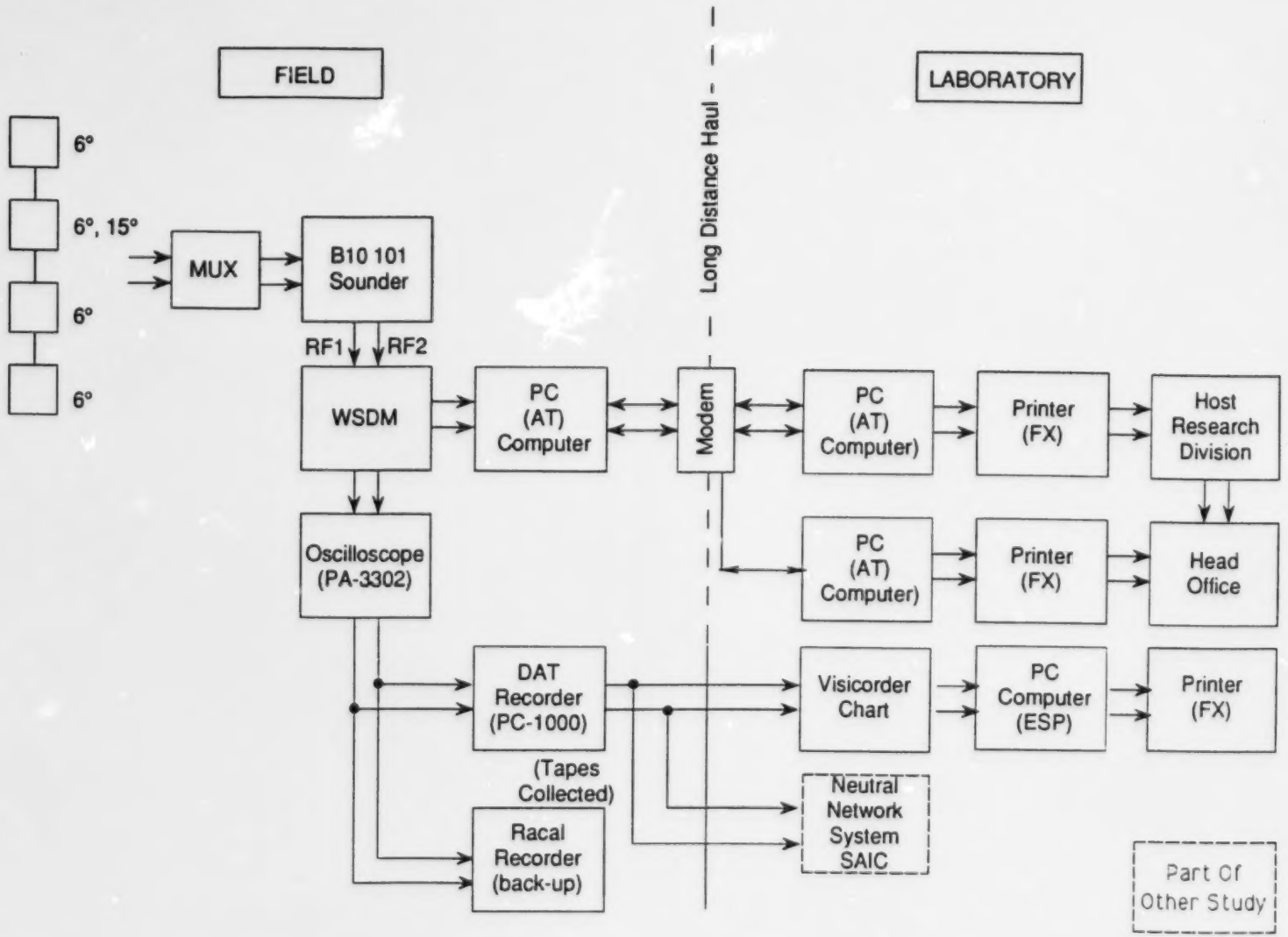



FIGURE 1

REMOTE COLLECTION AND ANALYSIS OF FISHERIES DATA
AT DARLINGTON NGS

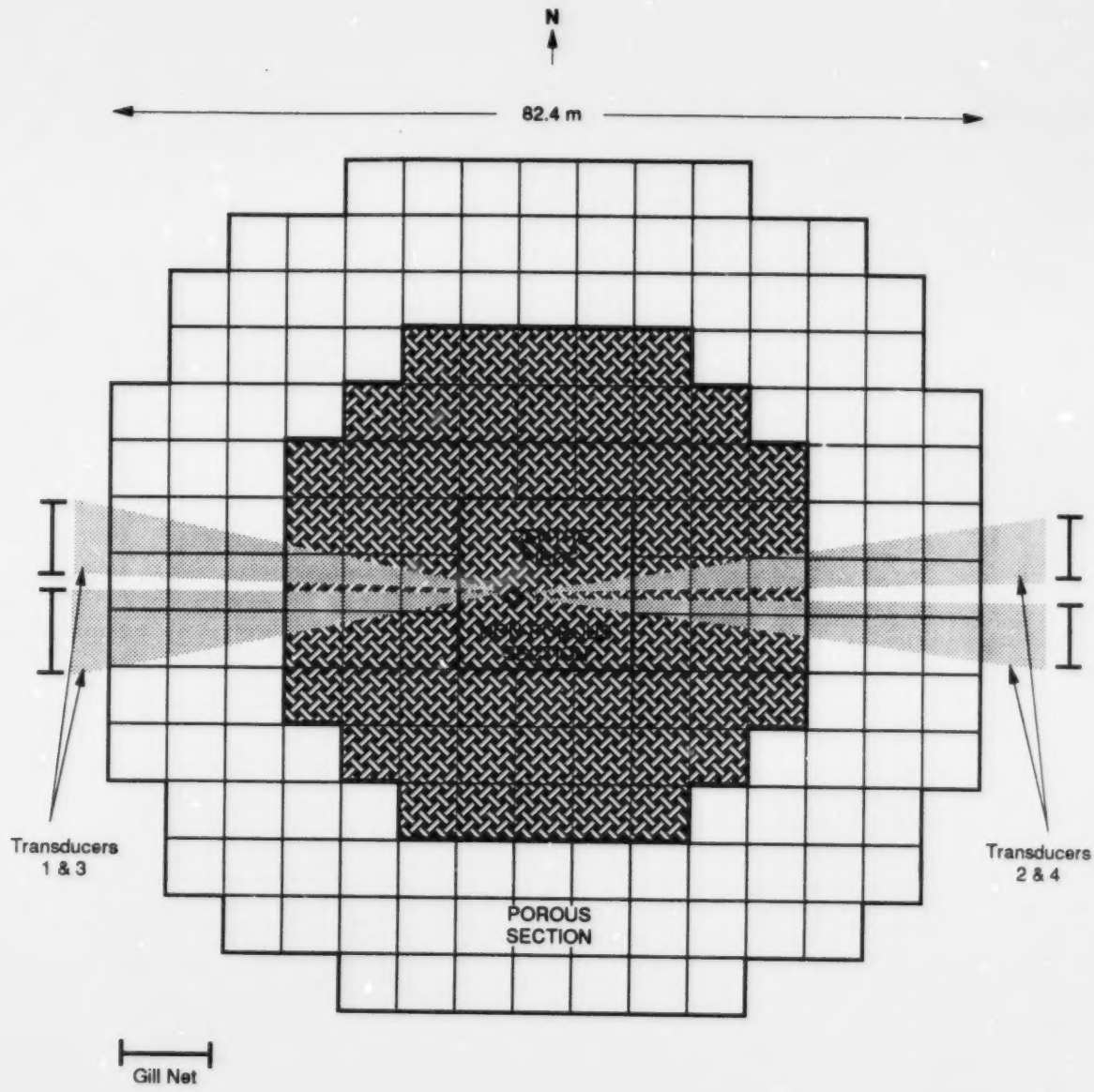
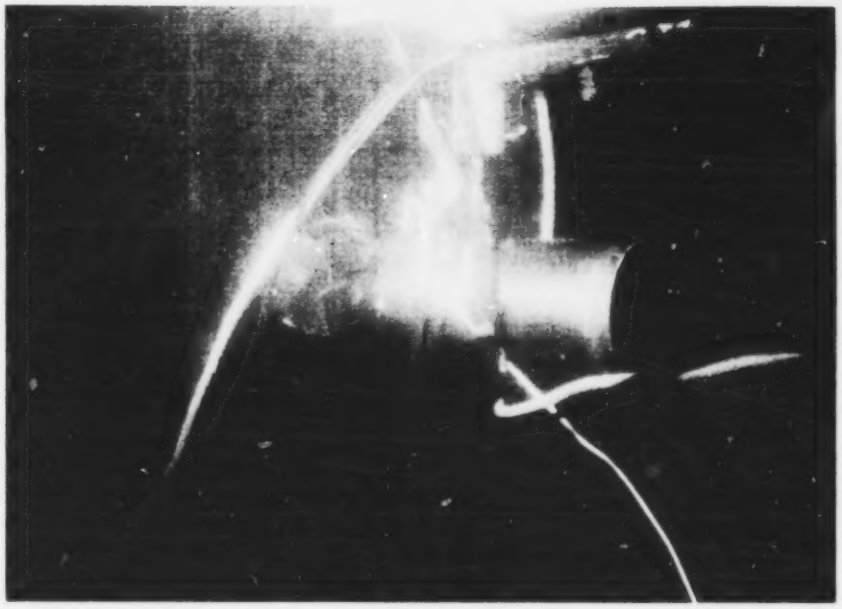


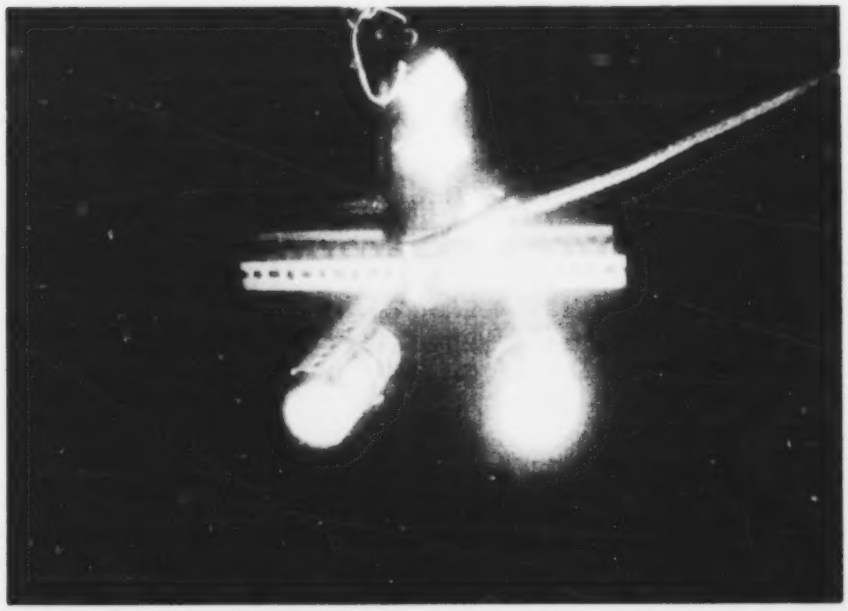

**FIGURE 2**

**DARLINGTON NGS INTAKE SURFACE STRUCTURE
- POSITION OF TRANSDUCERS (4)
AND GILL NETS (4)**

184331-C19-RD



Transducer #1
(dual beam)
showing rotator



Transducers
#2 and 4

**PLATE 1**

**UNDERWATER PHOTOS OF THE TRANSDUCERS POSITIONED AT THE DARLINGTON NGS INTAKE**

Sonar data were obtained during the spring (June 12 to 14), summer (July 23 to 25) and fall (October 16 to 17). Continuous recorded data were collected over 7 distance intervals (6-11, 11-16, 16-21, 21-26, 26-30, 30-35, and 35-40 m ) covering both porous and non-porous sections of the veneer (Figure 2). The recorder collected information over approximately a 8-minute period from each transducer before multiplexing to the next transducer (ie. transducer #1 collected data for 8 minutes followed by transducer #2 for 8 minutes, and so on). Although data collections are continuous, sampling from the same transducer (eg. transducer #1) occurs at approximately 32-minute intervals (ie. 4 transducers x 8 minutes). In the original survey design, we had hoped to have two pairs of replicates, but subsequently, we concluded that all transducers were making independent estimates. The transducers are not true replicates since they are slightly offset spatially and record approximately 16 minutes apart. Acoustic pulses were usually transmitted at 0.5 ms, although some data were also collected at lower pulse widths (0.05 and 0.1 ms). A ping rate of 2 pings/second was constant throughout the sampling period. The WSDM modification was used which was assumed to improve the range resolution of targets by at least 30% based on laboratory results (Patrick et al. 1991, OHRDR 89-21-H).

A total of eight gill nets (15.5 m length, 1.5 m depth) were set for the June 12-14 and July 24-25 collection periods. One net was set in front of each transducer (4) overnight (approximately a 12 h period) for each day of sampling (2). The gill nets were placed approximately 55 m from the transducers as shown in Figure 2. The sonar beam did not cover the gill nets (coverage was up to 40 m). Therefore, the gill nets and sonar collected samples from spaces which at least 15 m apart. Alewife were targeted as the dominant fish species with a 3.8 cm mesh stretched net. These fish were sampled because it was known from previous gill net surveys (Sheehan 1990 draft) that these fish would show up as the most abundant targets in the acoustical assessment. This has been confirmed by consultants (Tarandus October Progress Report). The 3.8 cm mesh size was also used in October since large numbers of alewife were observed (diver observation) in the vicinity of the veneer during this period. However, it was expected that these catches would be biased towards a lower estimate of fish abundance since species other than alewife caught in other mesh sizes are more abundant during this period. A comparison of mean catches in nets positioned both side-by-side and at two different locations (east and west, Figure 2) were made for each sampling date using analysis of variance techniques. Data were log transformed prior to analysis to meet the assumption of normality.

Preliminary sampling was also conducted with a single transducer positioned vertically in a mobile mode (boat operating). This was done only in July to determine the vertical distribution of fish echoes in the water column (above the veneer).

### 2.1.3 Data Collection and Analysis

Sonar records together with impingement data were used to evaluate the effectiveness of the veneer intake in reducing fish impingement. Impingement

records gave a daily estimate of the number of fish impinged. Continuously recorded sonar records were compared to these impingement records by estimating the number of fish encounters in the vicinity of the veneer intake (within 5 m of the bottom). Echo returns were classified conservatively as "fish echoes" rather than fish since one fish may be responsible for more than one echo. This is a limitation of a fixed horizontal system since the same fish could be counted more than once as it moved in the acoustical cone (either away or towards the transducer). This is not considered a problem with mobile sonar assessments. Fish echo data were summarized for each transducer over each 8-minute period, and included the following:

- Spatial distribution of fish echoes at various time periods at the selected distance intervals- NUMBERS in vicinity of veneer. Data were summarized at approximately 5 m distance intervals over a 40 m distance. This coverage included both non-porous and porous sections (Figure 2). The non-porous distances ranged from approximately 6 to 21 m for transducers #1 and #3, and from approximately 6 to 26 m for transducers #2 and #4. The porous sections ranged from approximately 21 to 40 m for transducer #1 an #3, and 26 to 40 m for transducers #2 and #4. The overall distance intervals between porous and non-porous sections were comparable.

- Temporal distribution of fish echoes at various time periods at the selected distance intervals - NUMBERS in vicinity of veneer. The day-night periods were divided into 12 h components (0800 to 20:00, 20:00 to 0800).

- Preliminary target strength estimates were also made at selected distance intervals (6 and 15 degree beams only). Information on this parameter gives some insight into size of target.

Information was also obtained on sampling variability for each transducer (side-by-side and different directions - east and west, Figure 2). Comparisons of the mean number of fish echoes among transducers (transducers 1, 2, 3 and 4), location (porous vs non-porous) and time of sampling (day vs night) were made using analysis of variance. Data were log transformed prior to analysis to meet the assumption of normality. All data were corrected for cone volume prior to analysis.

Data were processed using a state-of-the-art echo signal processor (Biosonics ESP) which was used to maximize the probability that the echo returns were indeed from fish. This processor compares each echo return to specified voltage and pulse width criteria, and accepts only those echoes which meet those criteria. These "accepted" echoes are further processed into various depth intervals. Data input into the processor was somewhat labour intensive since it involved processing the digitally recorded tape. Recent modifications to equipment has resulted in data being collected and processed in an automatic fashion thereby reducing labour requirements. For additional information on the ESP consult Dawson et al. 1989.

The sonar equipment performed well during each sampling period. The only exception was transducer #3 during the June and October sampling periods where problems were experienced with the transducer cable. These data were not used. Typical signal-to-noise ratios (SNR) found at each sampling date are shown in Figure 3. Noise levels were usually always low (below 0.15 volt) for each transducer (over approximately a 40 m distance). Echo returns from targets for transducers either in fixed (horizontal) or mobile (vertical) mode usually gave a voltage level considerably above the noise threshold. Noise interference (reverberation) was sometimes evident at 45-50, and 45-50 m from each transducer. This was partly related to the acoustical cone touching the bottom at this distance adding interference to the signal. Observations from 6 to 40 m from the transducer were only used (which was considered to give an accurate assessment of fish echo returns).

### 2.2 Low Frequency Sound Studies

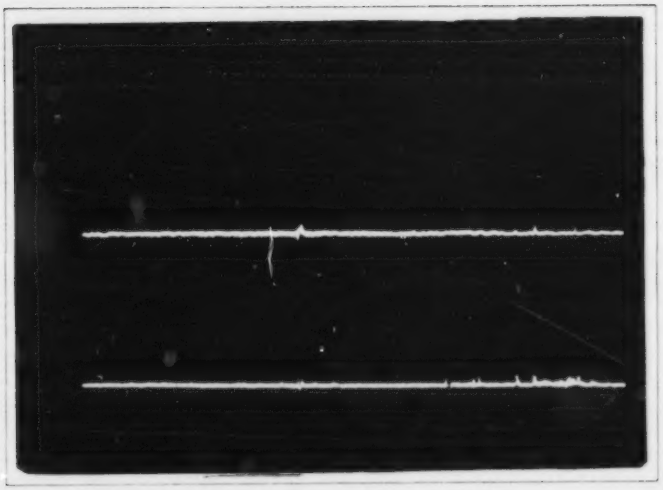
Another hydroacoustic technique has been investigated by research which involves applying low frequency broadband sound (continuous or intermittent) to resonate swimbladders of fish present in a given area (OHRDR 90-25-H). A potential advantage of this technique over high frequency sonar is that the area of coverage can be considerably larger, and fish assessment can be conducted in noisy, fast flowing environments. A potential application of this technology is to assess fish numbers that actually enter the intake ports of the veneer. Low frequency sound is omni-directional (ie vertical as well as horizontal coverage). Preliminary experiments were conducted using this technique in the laboratory and field.

## 3.0 RESULTS AND DISCUSSION

### 3.1 Impingement and Number of Fish Echo Encounters

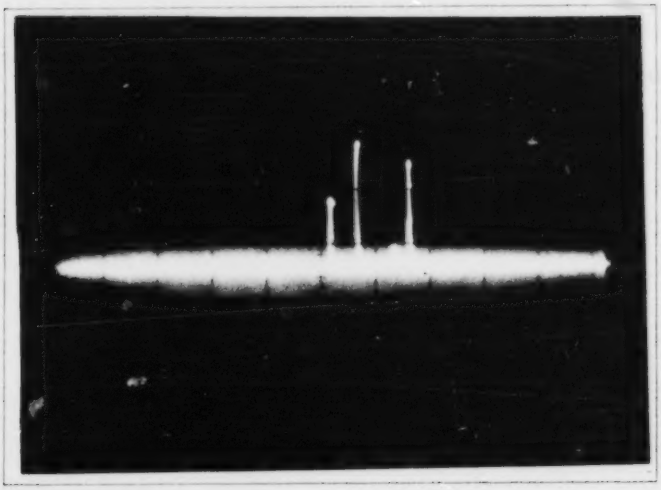
The number of fish impinged were minimal during the sampling periods (Table 1). No fish were impinged in June when station flow rates were minimal (38.7 m3/s). The mean number of fish encounters (sonar echoes) during this period averaged approximately 123 fish echoes/transducer/8 minutes (Table 1). These fish echoes were assumed to be alewife based on gill net catches (99.9% alewife) and diver observations (Plate 2). A preliminary inspection of the target strength data suggested small fish when fish echo counts were low. Interpretation of the sonar signals (ie species identification) using an artificial intelligence system will occur elsewhere (not part of Darlington study).

During July (22-25), only 12 fish were impinged, half of which were alewife. In contrast, the number of fish echoes encounters were quite high, averaging approximately 2538 fish echoes/transducer/8 minutes during the continuous 45 h sampling period (Table 1). These data suggest that the veneer was very effective in preventing fish passage. Station flows in July were, however, also low averaging approximately 49.9 m3/s (ie only one unit was operating). Similar to the sonar data, the gill net data showed a higher CUE in July (159.4/12 h set) than June (39.7/12 h set). Fish caught in the gill nets were primarily alewife (99%) which was consistent with diver observations (Plate 2). The raw gill net data are given in Appendix C.



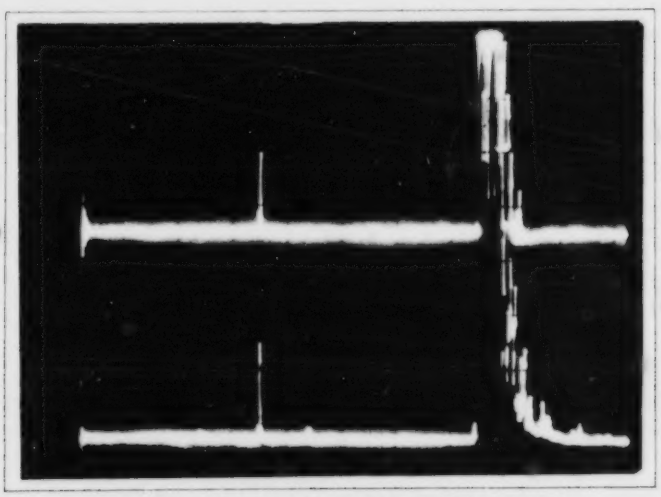
Fixed Mode
(Horizontal)

A. No targets present (June 13 0800)



Fixed Mode
(Horizontal)

B. Targets present in vicinity of veneer (July 22 1900)



Surface

Bottom
(Veneer cap)

C. Targets present in mobile mode (vertical)
(July 2200)

**FIGURE 3**

**SNR IN VARIOUS SITUATIONS AT DARLINGTON NGS**
**(JUNE - JULY 1990)**
**420 kHz TRANSDUCER**

91-36
184322-B25-RD

In October, few fish were impinged. Similarly, few encounters of the intake occurred based on both gill net catch (CUE 3.2/12 h set) and sonar observations (x = 52.3/transducer/8 minutes, Table 1). Although some alewife schools were observed (diver observation), most of these had moved offshore. Besides alewife, other species collected in the net included round whitefish (3), lake trout (4), white sucker (1) and lake chub (2). As mentioned above, these net results may be biased towards a low estimate of abundance because of the net size used (3.8 cm mesh).

High temporal variability (process error) was observed in the sonar data (shown as standard deviations in Table 1). Coefficients of variation of 8-minute estimates in the June data ranged from 94.3% for transducer #1 to 192.4% for transducer #4. Similarly, the July data also had high coefficients, ranging from 156.9% for transducer #1 to 202.9% for transducer #4. High variability was attributed to large fluctuation in fish echoes due to expected offshore-onshore movements of fish and/or diurnal differences in activity between day and night periods. For instance, the number of fish echo counts from transducer #1 were as high as 19,000 counts/8 minutes during the night, and as low as zero during parts of the day (Figures 4 to 6, and Appendix B). Spatial sampling error over the survey period (variability in the mean estimates of echoes/transducer/survey) was estimated to be less than the temporal process error. Coefficients of variation ranged were estimated to be 36.5% for the June data (means of transducers #1, 2 and 4-6 to 40 m ) and 35.7% for the July data (means of transducers #1, 2, 3 and 4-6 to 40 m). The gill net data showed coefficients of variation between sets of 30.1% for the June data (n=8) and 111.3% for the July data (n=8).

### 3.2 Temporal Distribution of Acoustic Targets

The temporal distribution of fish echoes observed diurnally in June, July and October are shown in Figures 4, 5 and 6. As mentioned earlier, highest number of fish echoes were recorded in July, followed by June and October. For June, there was an apparent increase in echo counts at night compared to the day. This was found to be statistically significant ($F_{1,103} = 6.54$, $P<0.01$, Table 2). Highest counts were recorded at 03:55 for transducer #1 (396), at 19:47 for transducer #2 (459), and at 20:03 for transducer #4 (1421, Appendix B). Lowest counts (0) were observed usually during the early day. In contrast, highest counts in July occurred earlier in the day than in June, and were generally highest in the late afternoon or early evening periods (Figure 5 and Appendix B). A statistical comparison of the July data indicated higher counts during the day (between 0800 and 20:00 $F_{1,600} = 19.7$, $P<0.01$, Table 2). Another difference between the June and July data was that the July data appeared to show more evenness in echo distribution over a given 24 h period (Appendix B). This is possibly related to a greater spawning activity during July. It may also be related to the larger number of data points (8-minute sampling intervals) in July compared to June. Although a statistical comparison with the October data was not made because of the few number of fish echoes observed (Burnham 1990), there was no evidence of any temporal preference during a 24 h period (Figure 6).

**TABLE 1**

**NUMBER OF FISH COLLECTED IN GILL NETS AND OBSERVED USING SONAR AT DARLINGTON NGS**

| DATE | LOCATION | GILL NETS (#~12 H/SET) N $\bar{X}$ +/-SD (X) | SONAR (# FISH ECHOES/8 MIN) N $\bar{X}$ +/-SD (X) | IMPINGED (# WEEK) |
|---|---|---|---|---|
| Jun 12-14 | Trans. #1 | 2 36.0 +/-22.6* | 10 125.7 +/-118.5 | |
| | Trans. #2 | 2 34.5 +/-14.8* | 22 77.0 +/-114.7 | None |
| | Trans. #3 | 2 38.5 +/-4.9* | - - | |
| | Trans. #4 | 2 50.0 +/-1.4* | 22 166.8 +/-320.9 | |
| | | 8 39.7 +/-12.3 | 54 122.6 +/-227.9 | |
| Jul 23-25 | Trans. #1 | 2 42.0 +/24.0* | 75 2622.2 +/-4113.7 | |
| | Trans. #2 | 2 156.5 +/154.8* | 76 3107.2 +/-5784.6 | 6** |
| | Trans. #3 | 2 31.5 +/-3.5* | 77 1238.6 +/-2249.1 | 6** |
| | Trans. #4 | 2 407.5 +/-111.0* | 76 3215.0 +/-6522.8 | |
| | | 8 159.4 +/-177.4 | 303 2538.0 +/-5002.4 | |
| Oct 16-17 | Trans. #1 | 1 2 | 37 96.4 +/- 138.9 | |
| * * * | Trans. #2 | 1 4 | 37 31.9 +/- 54.7 | |
| | Trans. #3 | 1 3 | - - - | None |
| | Trans. #4 | 1 4 | 37 30.3 +/- 53.8 | |
| | | 4 3.1 +/-0.7 | 111 53.40+/-96.69 | |

* alewife (100%), ** alewife, emerald shiners
*** set was approximately 18.5 h

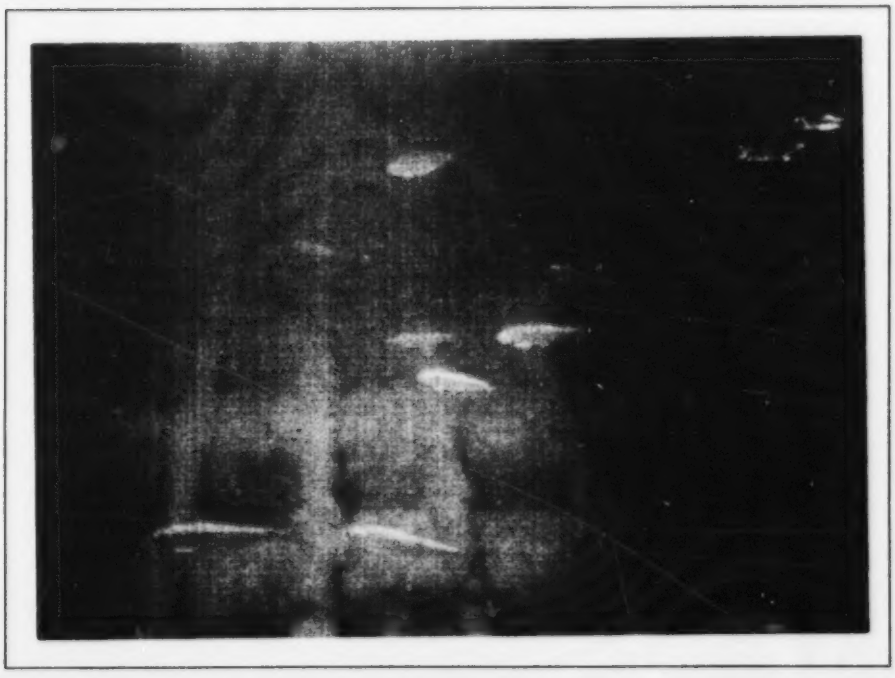


**PLATE 2**

**UNDERWATER PHOTOS OF ALEWIFE OBSERVED IN THE VICINITY OF THE DARLINGTON NGS VENEER (JUNE - JULY, 1990)**

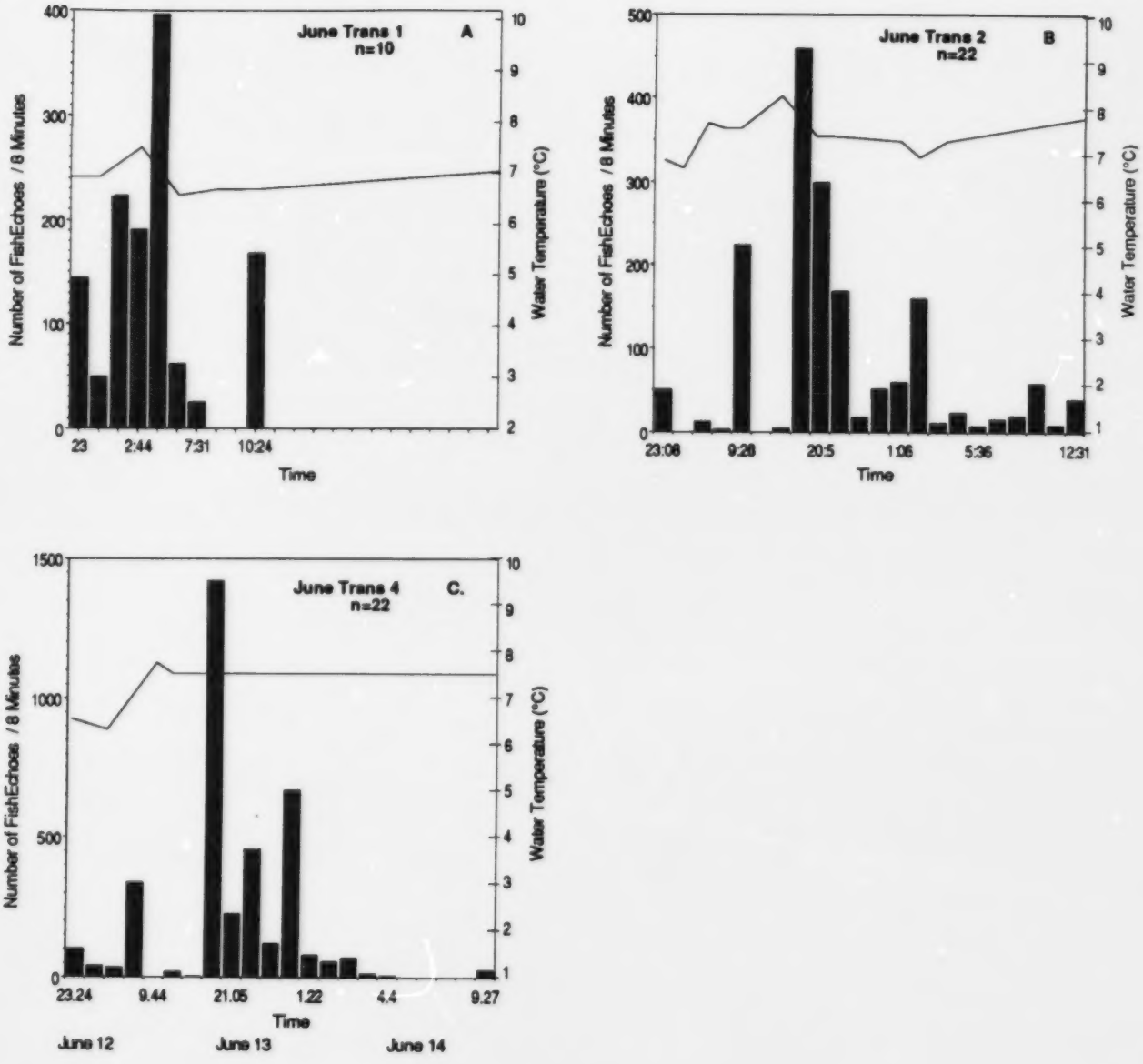



**FIGURE 4**

**TEMPORAL DISTRIBUTION IN THE NUMBER OF FISH ECHOES OBSERVED IN THE VICINITY OF THE DARLINGTON VENEER (JUNE 1990). (A. TRANSDUCER #1, B. TRANSDUCER #2, C. TRANSDUCER #4).**

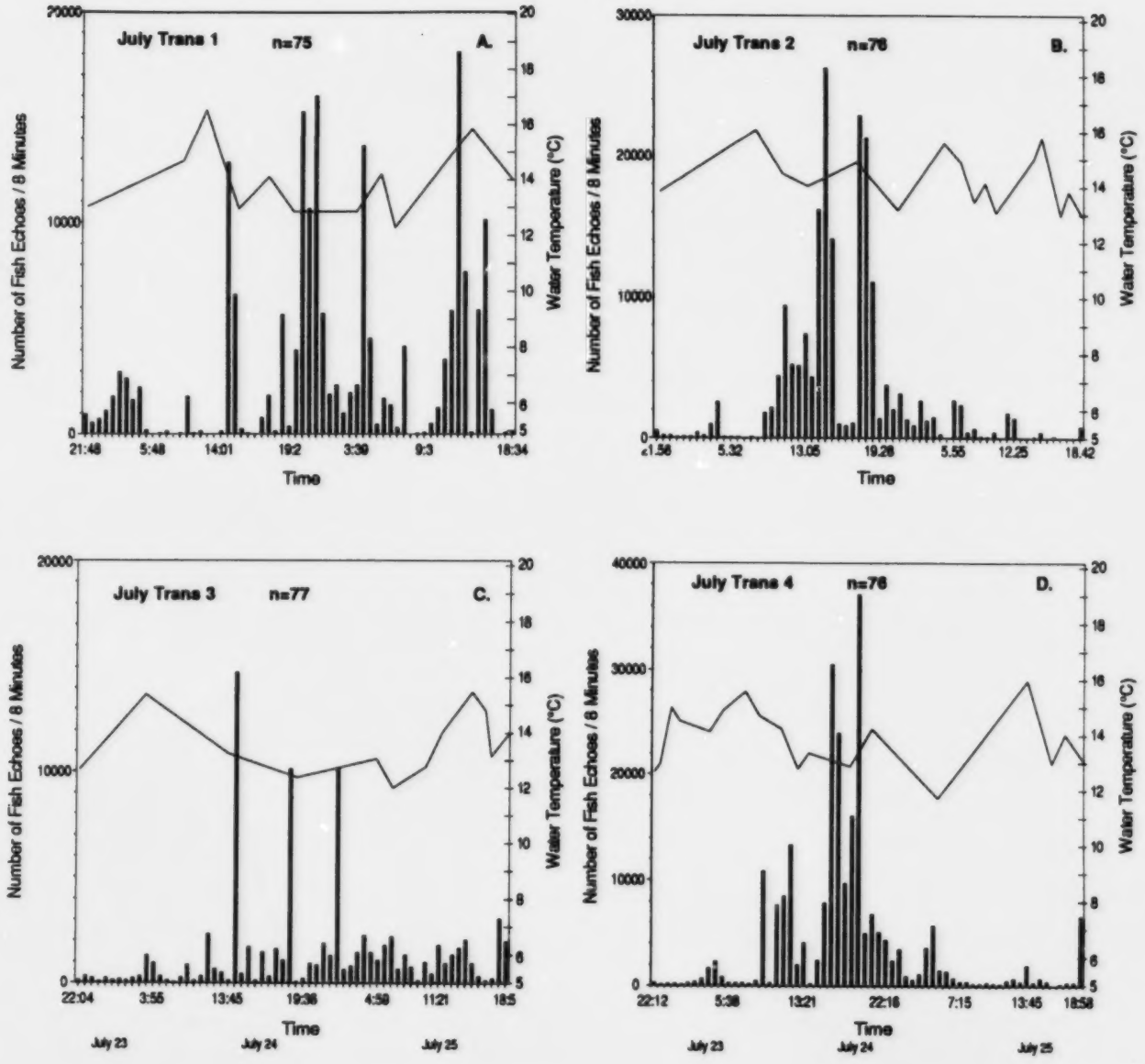



**FIGURE 5**

**TEMPORAL DISTRIBUTION IN THE NUMBER OF FISH ECHOES OBSERVED IN THE VICINITY OF THE DARLINGTON VENEER (JULY 1990). (A. TRANSDUCER #1, B. TRANSDUCER #2, C. TRANSDUCER #3 AND D. TRANSDUCER #4).**

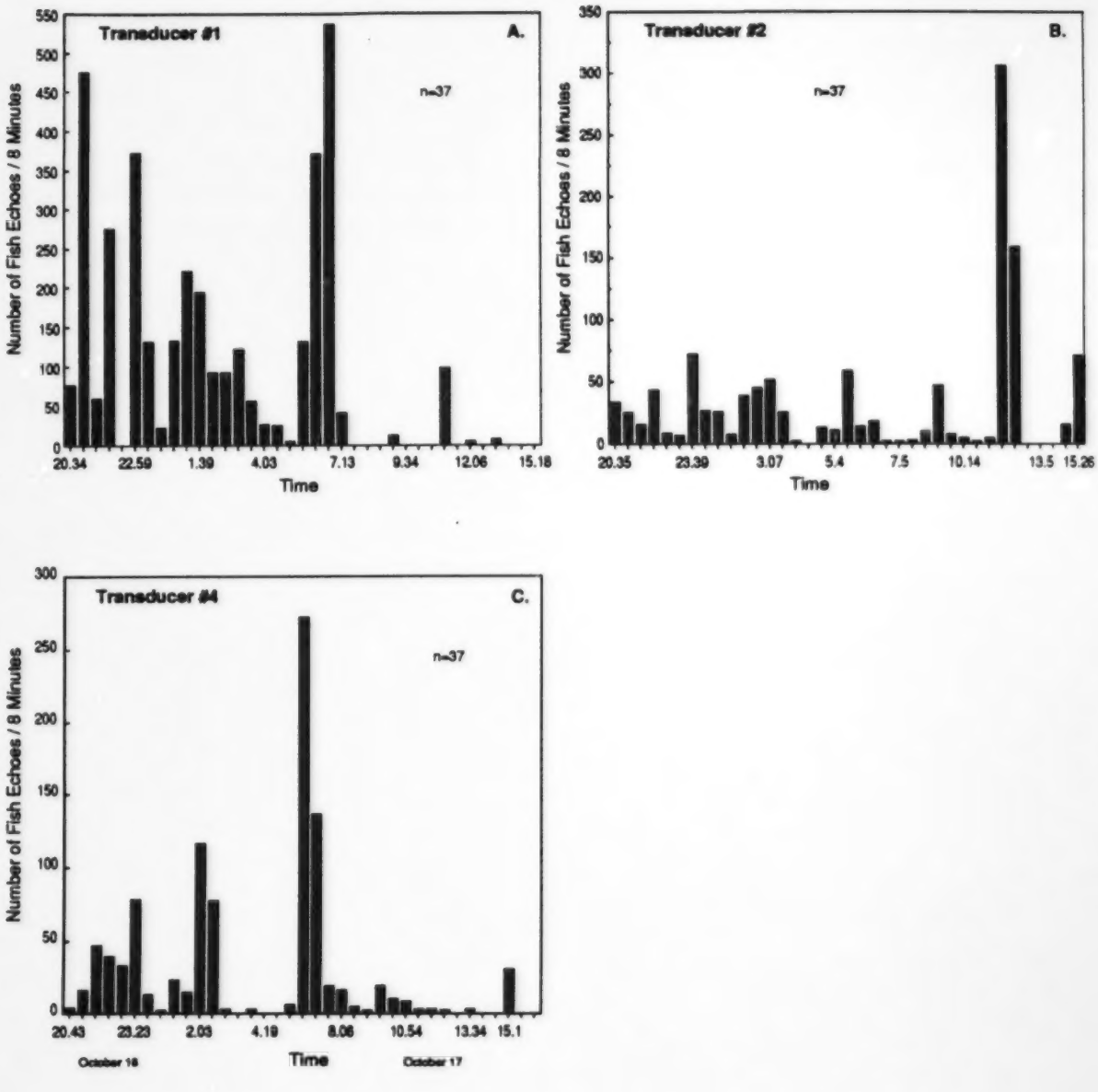



**FIGURE 6**

**TEMPORAL DISTRIBUTION IN THE NUMBER OF FISH ECHOES OBSERVED IN THE VICINITY OF THE DARLINGTON VENEER (OCTOBER 1990). (A. TRANSDUCER #1, B. TRANSDUCER #2, AND C. TRANSDUCER #4).**

A preliminary inspection of the temperature data (8 m depth) suggested that there was no apparent relationship between temperature and fish echo distribution for the June and July data (Figures 4 and 5). Temperature did not vary substantially over each 24 h period (slight change in the July data). The October data are not yet available. However, there may have been a relationship among periods (June vs July).

**TABLE 2**

**ANOVA (3- WAY) COMPARISONS OF SONAR AND GILL NET DATA FOR JUNE AND JULY SAMPLING PERIODS**

A. SONAR DATA

| Date | Treatment | d.f. | F-statistic | Probability |
|---|---|---|---|---|
| Jun | Transducers (1,2 & 3) | 2,103 | 0.86 | 0.42 ** |
| | Area (porous vs non-porous) | 1,103 | 1.54 | 0.22 |
| | Time (day vs night) | 1,103 | 6.54* | 0.01* |
| Jul | Transducer (1, 2, 3 & 4) | 3,600 | 2.2 | 0.08 ** |
| | Area (porous vs non-porous) | 1,600 | 26.6* | 0.01* |
| | Time (day vs night) | 1,600 | 19.7* | 0.01* |

B. GILL NET DATA

| Treatment | d.f. | F-statistic | Probability |
|---|---|---|---|
| Month (Jun vs Jul) | 1,9 | 5.2* | 0.04* |
| Location (East vs West) | 1,9 | 7.4* | 0.02* |
| Side-by-Side | 2,9 | 1.4 | 0.29 |

* significant effect
** transducer effect includes both location (east vs west) and side-by-side effects (both are not significant)

### 3.3 Spatial Distribution of Acoustic Targets

Sonar data for each transducer were approximated into echo counts for both non-porous (6 to 21 or 26 m) and porous (21 or 26 to 40 m) sections (depending on transducer). The intent here was to determine if there was a marked variation (based on fish echo counts measured by temporal abundances) by fish for the porous sections of the veneer where flow was present. An attraction to the porous section would increase the number of fish encounters (and possibly also duration) which could result in increased fish impingement. In June there was no significant difference noted in the number of fish echoes between porous and non-porous sections of the veneer ($F_{1,103} = 1.54$, $P>0.05$, Table 2). Mean echo counts over the non-porous section ranged from 58.5 counts/8 minutes for transducer #1 to 141.2 counts/8 minutes for transducer #4 (Appendix B). In the porous section, mean number of echoes ranged from 25.6 counts/8 minutes for transducer #4 to 67.2 counts/8 minutes for transducer #2. High variability (standard deviations) occurred for each mean estimate. The statistical analysis suggested that there was no apparent attraction to the porous sections under the existing flow regime. Similarly, in July, there was no evidence of an increased preference for the porous section of the veneer. (The ANOVA results actually showed a preference for the non-porous section, $F_{1,600} = 26.6$, $P<0.01$, Table 2), Overall, mean echo counts (all transducers combined) were 1606.5 counts/8 minutes for the non -porous section compared to 867.8 counts/8 minutes for the porous section.

The temporal distribution of fish echoes in June for both porous and non-porous sections are shown in Figures 7 to 9. As mentioned above for the June sampling period (Section 3.2.), there was an obvious increase in echo counts at night compared to the day. This was also found to be statistically significant. In July, greatest activity appeared to be highest during the late afternoon to early evening periods (Figures 10 to 13) (also indicated in Section 3.2). The variability in hourly peak abundances between porous and non-porous sections (as shown in Figures 10 to 12) probably reflect fish movements and distributions in and out of the acoustical core.

Because the number of fish echoes observed were quite low, a statistical comparison of the fish echoes found in both porous and non-porous sections during October was not attempted (Burnham 1990). The temporal distribution of echoes during this time period is shown in Figures 14 to 16. There appeared to be no obvious preference shown as an increase in echo counts for porous vs non-porous sections of the veneer. However, it is noteworthy that hourly peaks in abundance did seem to vary with time of day (eg transducers #2 & #4).

### 3.4 Vertical Distribution

Some limited information of the vertical distribution of fish echoes was collected on July 25 (2145-2230). Fish echoes were divided into three approximate depth categories: surface to mid depth (2-5 m), mid depth (5-8 m) band mid depth to bottom intervals (8-11 m, Figure 17). Results indicated that echo distribution was relatively uniform throughout the water column. These observations showing fish distributed throughout the water column are consistent with earlier sonar observations conducted at Darlington in 1978 and 1979 (OHRDR 82-471-K), and netting results at the Pickering Fish Diversion

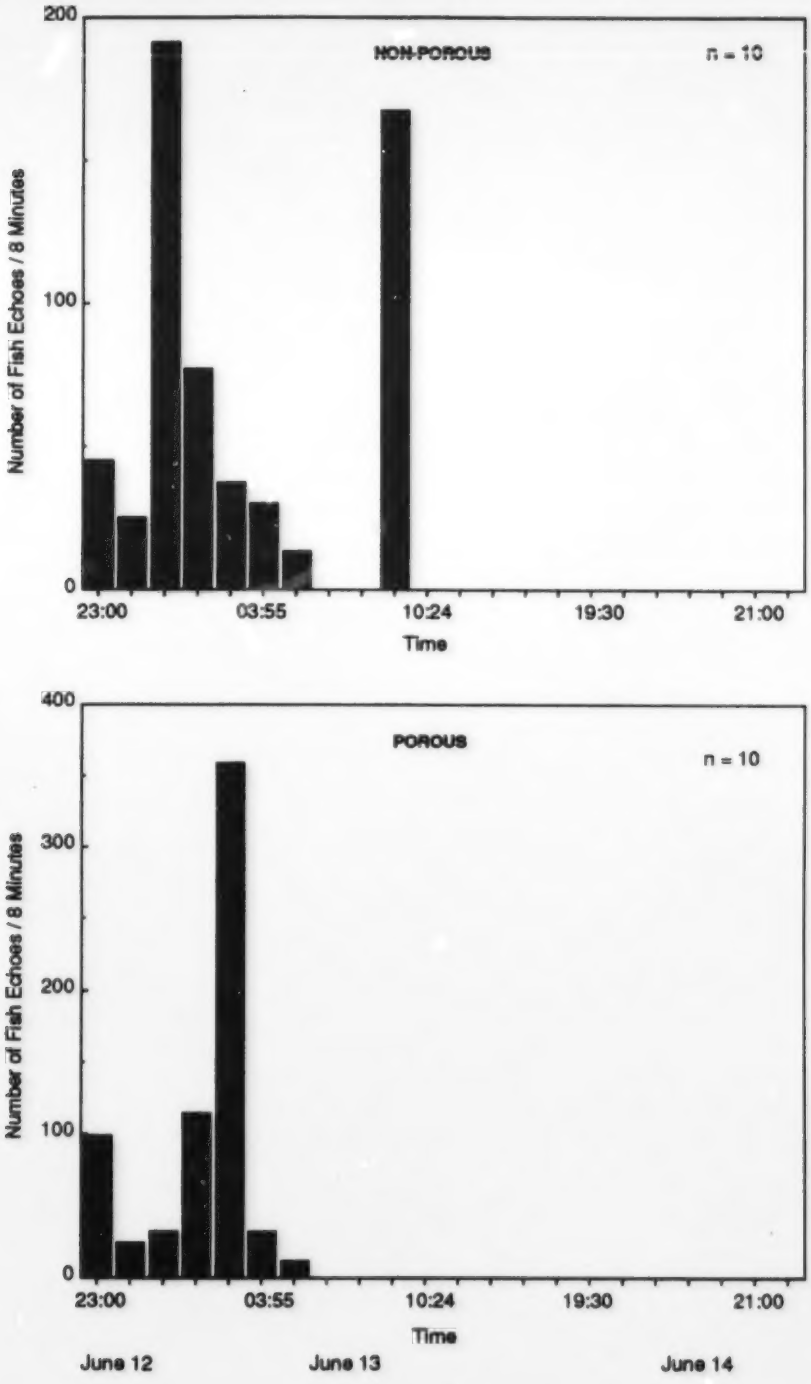



**FIGURE 7**

**NUMBER OF FISH ECHOES RECORDED IN NON-POROUS (6-21 m) AND POROUS (21-40 m) SECTIONS OF THE DARLINGTON VENEER (TRANSDUCER #1 JUNE 12-14, 1990)**

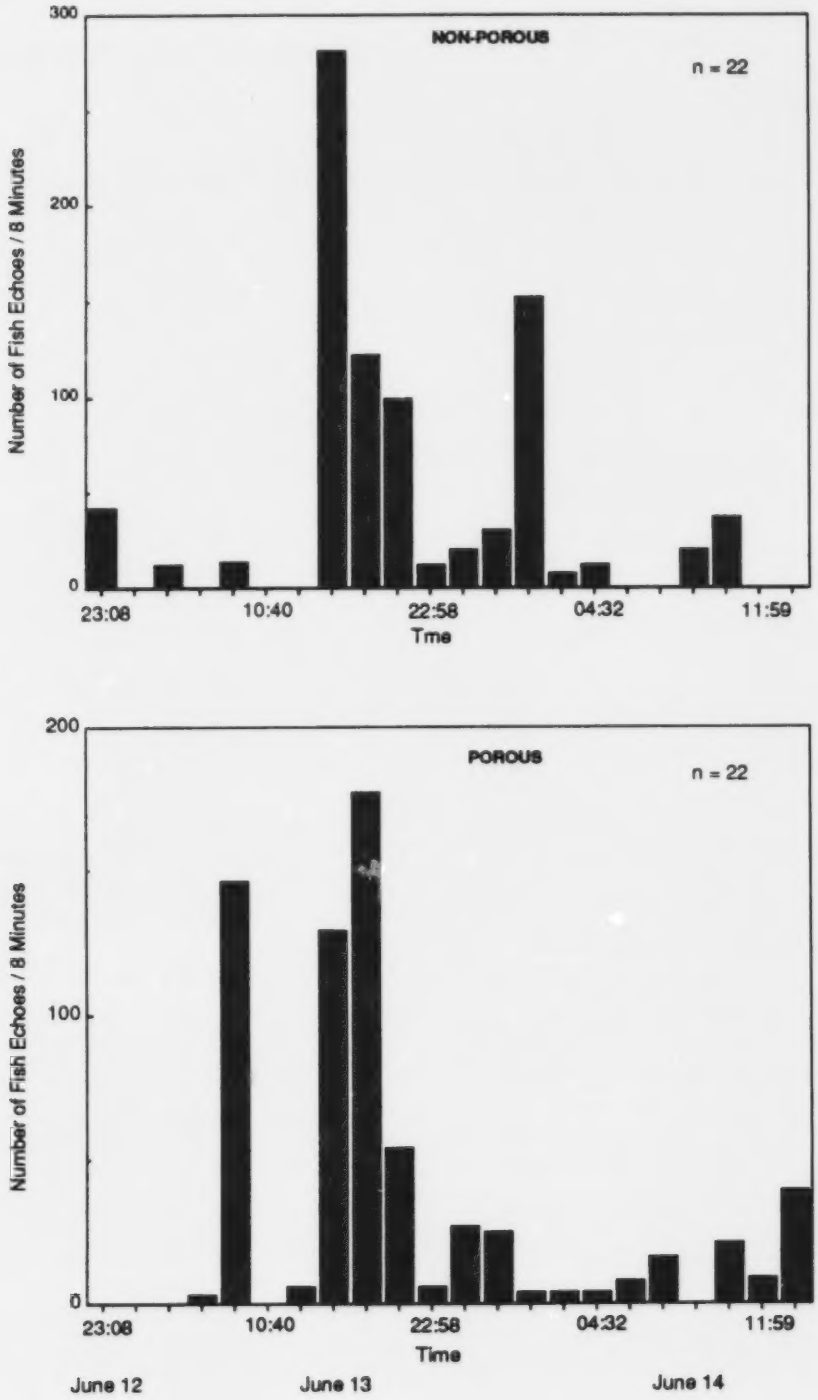



**FIGURE 8**

**NUMBER OF FISH ECHOES RECORDED IN NON-POROUS (6-26 m) AND POROUS (26-40 m) SECTIONS OF THE DARLINGTON VENEER (TRANSDUCER #2 JUNE 12-14, 1990)**

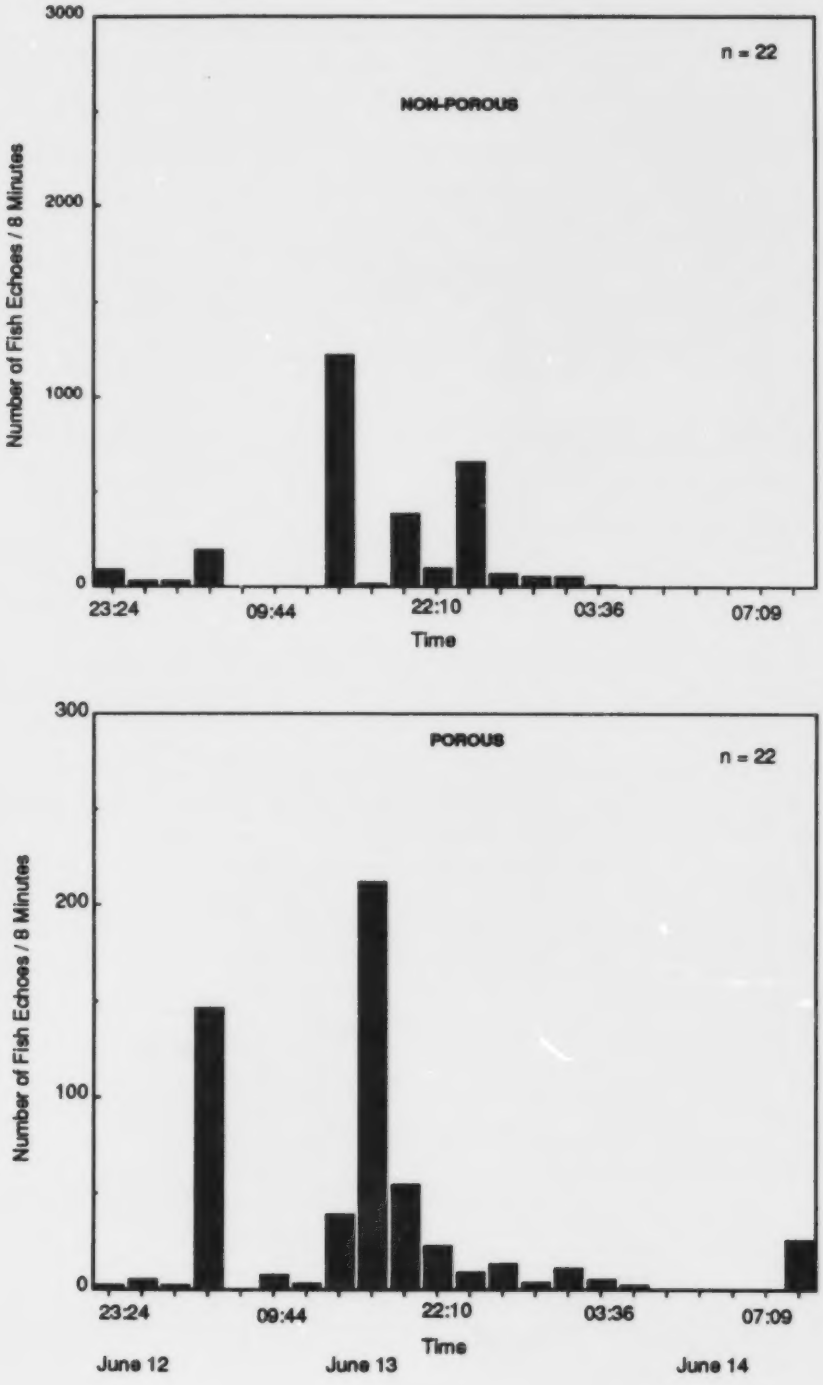



**FIGURE 9**

**NUMBER OF FISH ECHOES RECORDED IN NON-POROUS (6-26 m) AND POROUS (26-40 m) SECTIONS OF THE DARLINGTON VENEER (TRANSDUCER #4, JUNE 12-14, 1990)**

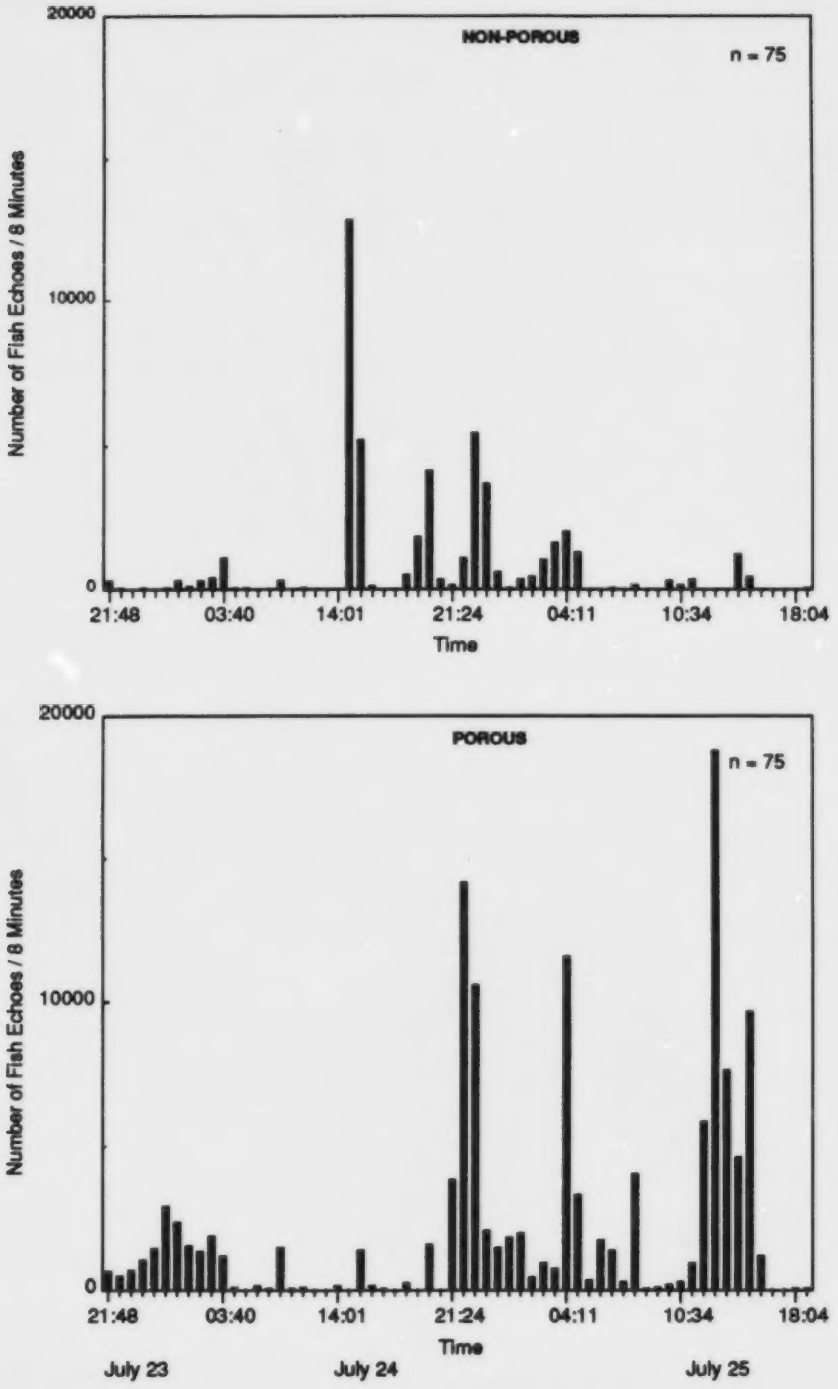



**FIGURE 10**

**NUMBER OF FISH ECHOES RECORDED IN THE NON-POROUS (6-21 m) AND POROUS (21-40 m) SECTIONS OF THE DARLINGTON VENEER (TRANSDUCER #1 JULY 23-25, 1990)**

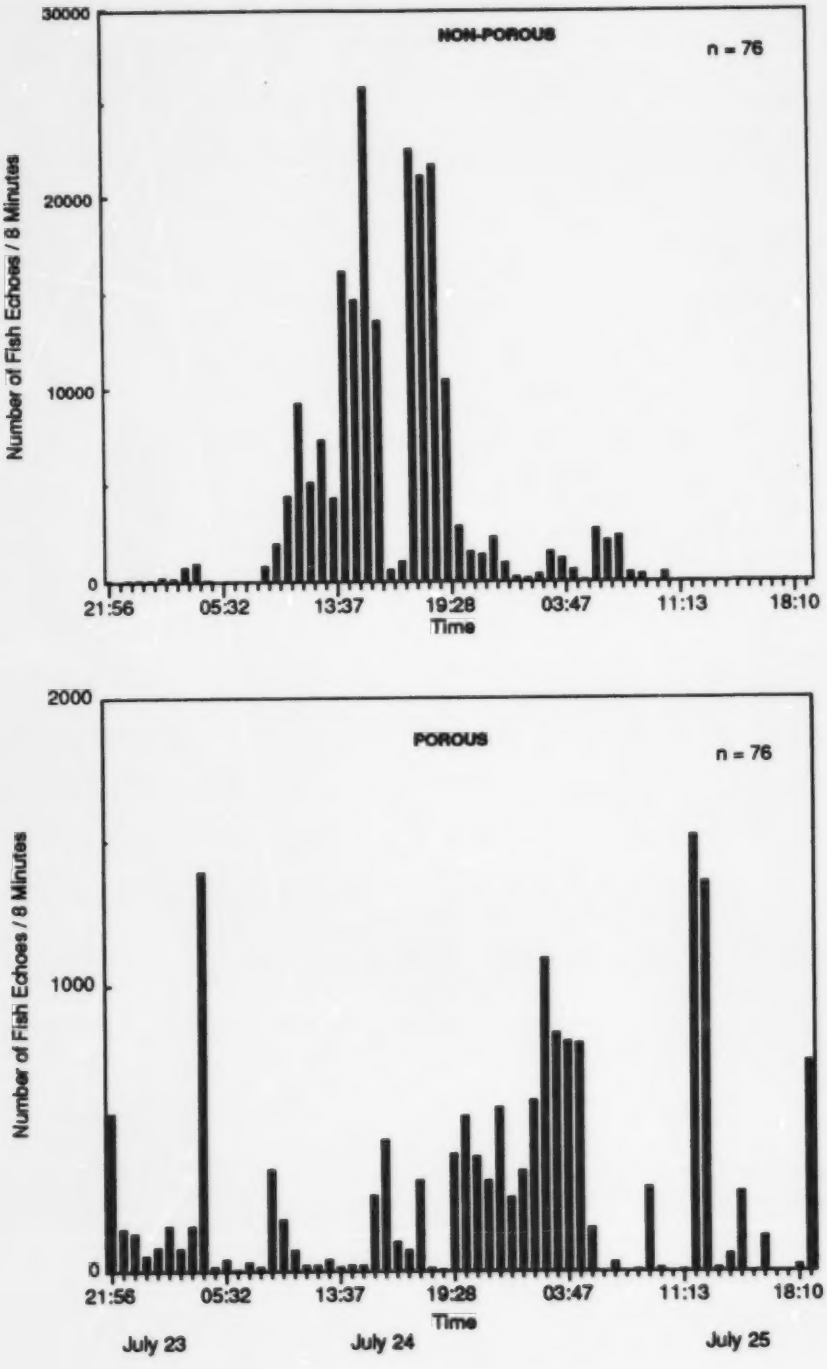



**FIGURE 11**

**NUMBER OF FISH ECHOES RECORDED IN NON-POROUS (6-26 m) AND POROUS (26-40 m) SECTIONS OF THE DARLINGTON VENEER (TRANSDUCER #2 JULY 23-25, 1990)**

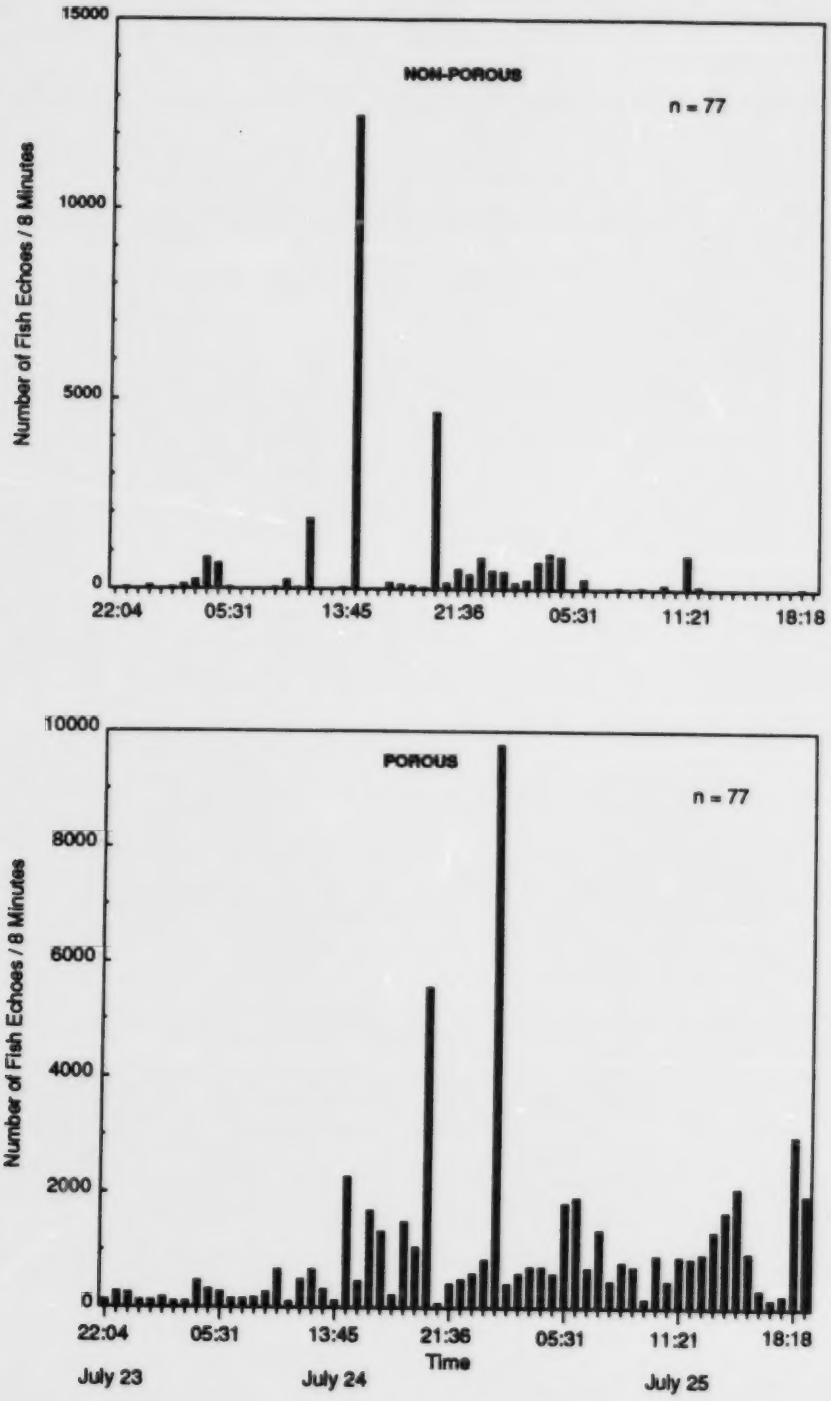



**FIGURE 12**

**NUMBER OF FISH ECHOES RECORDED IN THE NON-POROUS (6-21 m) AND POROUS (21-40 m) SECTIONS OF THE DARLINGTON VENEER (TRANSDUCER #3 JULY 23-25, 1990)**

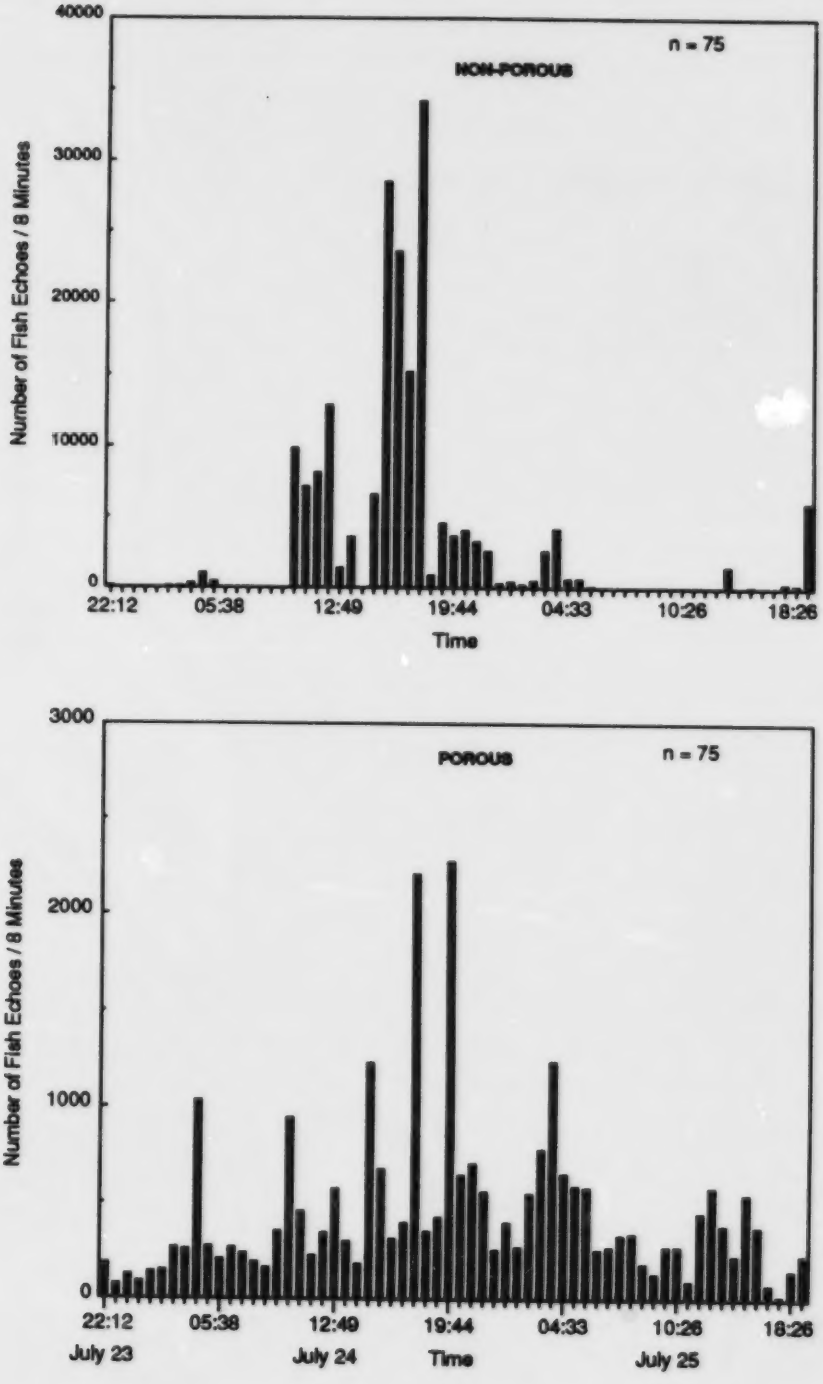



**FIGURE 13**

**NUMBER OF FISH ECHOES RECORDED IN NON-POROUS (6-26 m) AND POROUS (26-40 m) SECTIONS OF THE DARLINGTON VENEER (TRANSDUCER #4 JULY 23-25, 1990)**

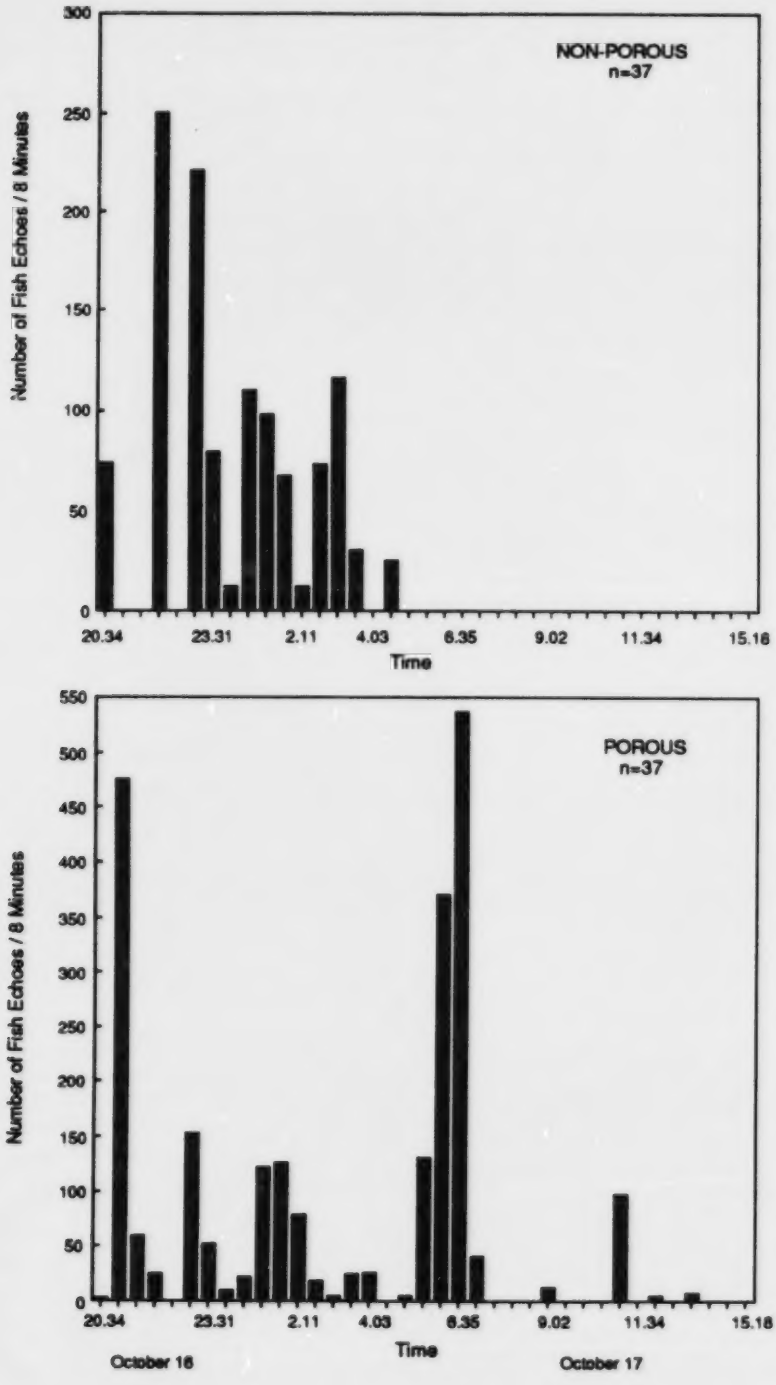



**FIGURE 14**

**NUMBER OF FISH ECHOES RECORDED IN NON-POROUS (6-21 m) AND POROUS (21-40 m) SECTIONS OF THE DARLINGTON VENEER (TRANSDUCER #1 OCTOBER 16-17, 1990)**

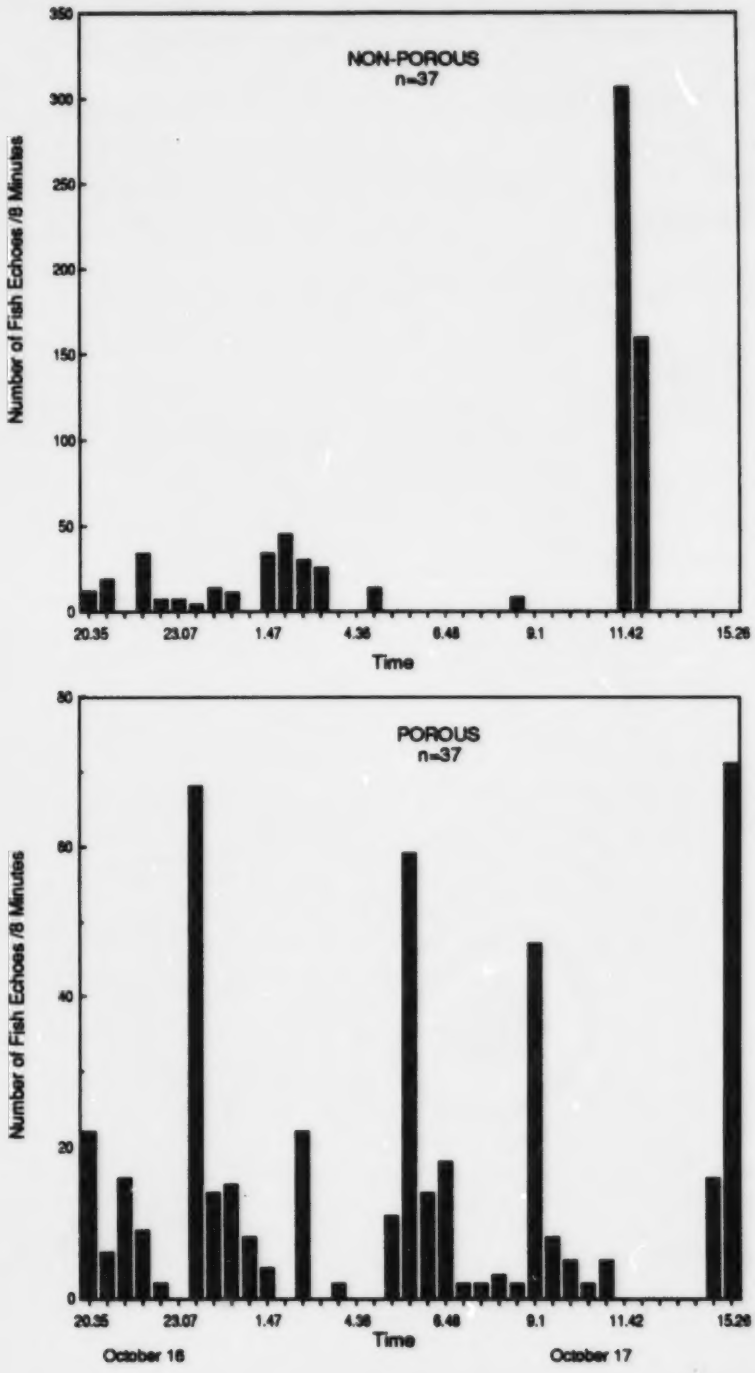



**FIGURE 15**

**NUMBER OF FISH ECHOES RECORDED IN NON-POROUS (6-26 m) AND POROUS (26-40 m) SECTIONS OF THE DARLINGTON VENEER (TRANSDUCER #2 OCTOBER 16-17, 1990)**

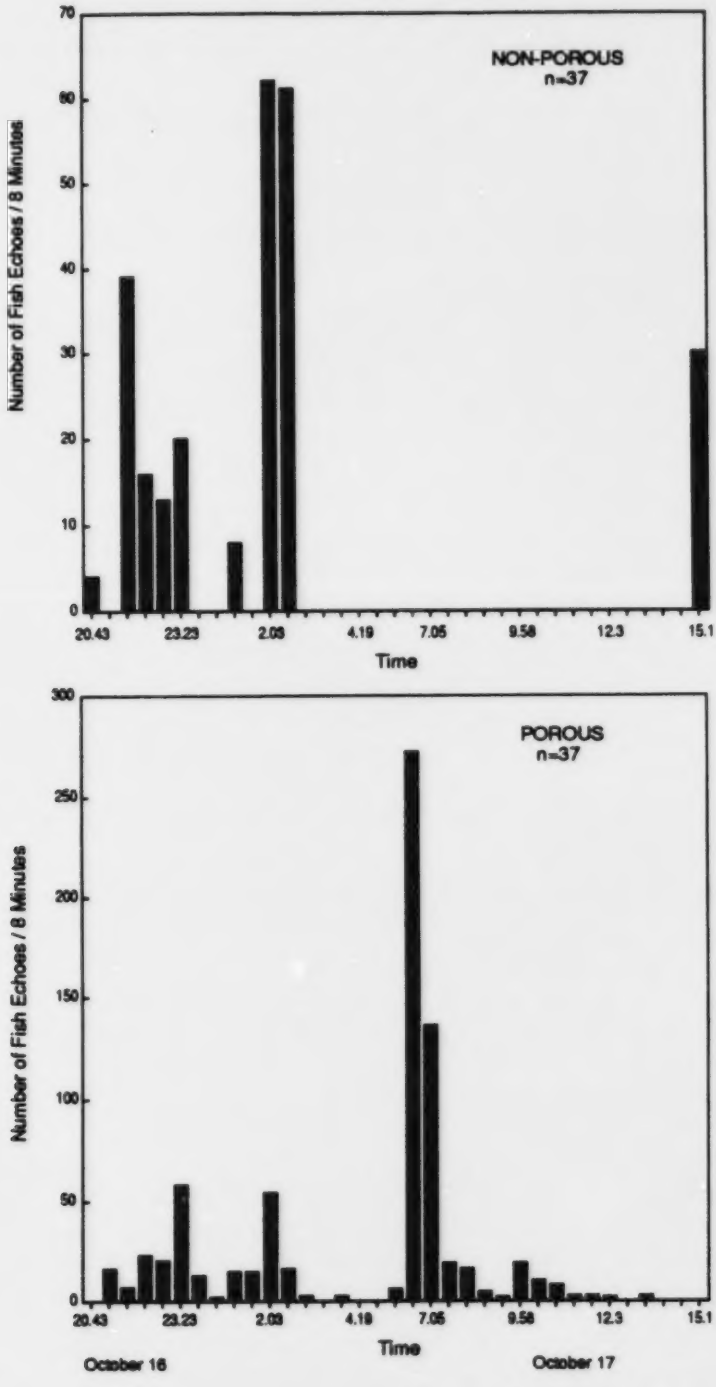



**FIGURE 16**

**NUMBER OF FISH ECHOES RECORDED IN NON-POROUS (6-26 m) AND POROUS (26-40 m) SECTIONS OF THE DARLINGTON VENEER (TRANSDUCER #4 OCTOBER 16-17, 1990)**

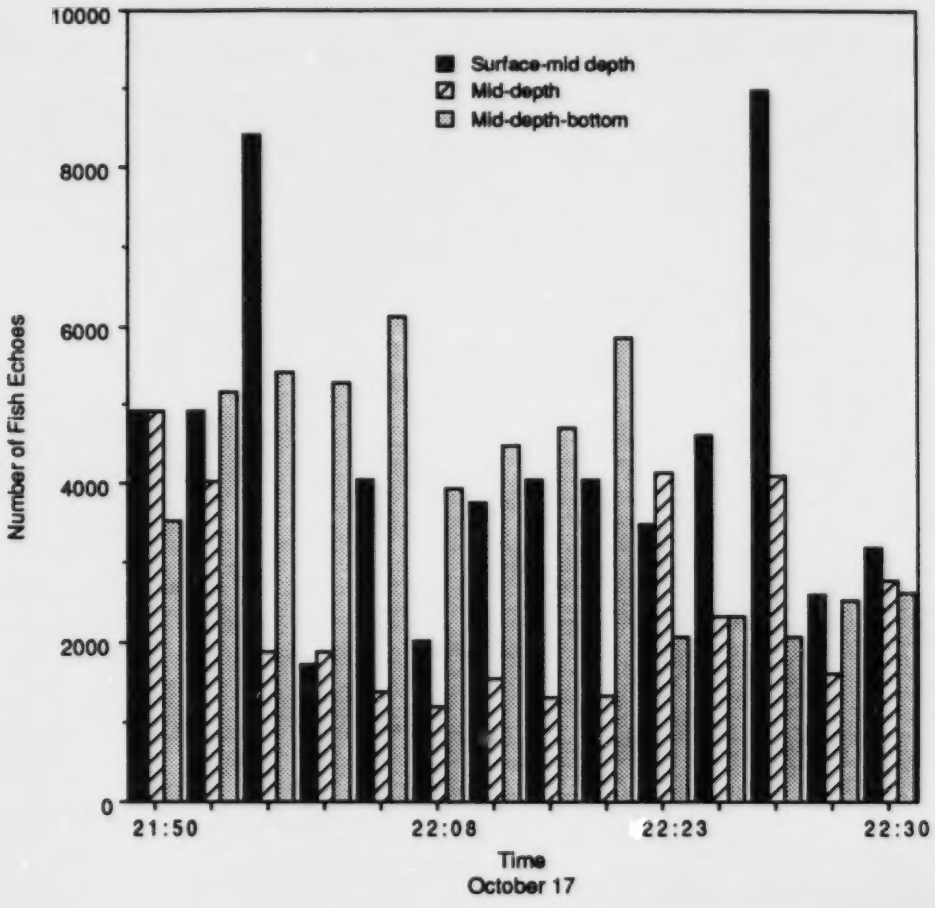



**FIGURE 17**

**VERTICAL DISTRIBUTION OF FISH ECHOES IN THE VICINITY OF THE DARLINGTON VENEER (JULY 25, 1990)**

### 3.5 Comparison of Gill Nets and Sonar

Both the gill net and sonar data showed some impingement trends (Table 1). Both sets of data indicated larger densities of fish (primarily alewife) in July, followed by June and October. Some differences were, however, apparent between both sampling methods. Consider, for example, a comparison in abundance estimates between the June and July sampling periods (assume 99% alewife based on net catches and visual observations see Plate 2). The gill net data indicated an increase in numbers between these months by a factor of 4.0. In contrast, the sonar data, showed a difference of 20 times in the number of fish echoes observed between the June and July dates (ie five times higher than suggested by the gill net data). Because of the inherent variability in both sampling methods (discussed in Section 3.1), it is difficult to state the preference of one system over the other at this time. This comparison would be feasible if impingement occurred (to a significant extent). One obvious advantage of sonar over gill netting is the amount of data that can be continuously recorded. For instance, the July sonar data had 75 or more data points compared to only 2 data points (two 12 h sets) for the gill net samples. Given this sampling effort, it is difficult for the netting results to accurately account for the continual movement of fish or reflect a reliable population size since fish are not always randomly distributed in the water column. This limitation of gill nets as a means of estimating abundance has been documented elsewhere (eg. Casselman et al. 1988). Although there are some inherent problems with sonar (such as species identification), it is accepted as a means of estimating fish populations and is currently being used by several researchers (eg. Dickie et al. 1983, Burczynski and Johnson 1986, Rose and Leggett 1988).

For the sonar data, there was no significant difference in the mean number of fish echoes observed between each transducer (June $F_{2,103} = 0.86$, $P>0.05$, July $F_{3,600} = 2.2$, $P>0.05$, Table 2). When fish densities were highest (July), the mean number of echoes varied from approximately 1239 fish echoes/8 minutes for transducer #3 to approximately 3215 fish echoes/8 minutes for transducer #4 (factor of 2.6), (Table 1). In contrast, the July CUE range for the gill net data was higher, ranging from 47 to 486/12 h set.

A statistical evaluation of the gill net data shows an interesting trend. Although the gill net catch did not vary significantly for nets positioned side-by-side ($F_{2,9} = 1.4$, $P>0.05$), there was a difference for nets located east and west of the veneer ($F_{1,9} = 7.4$, $P<0.05$, Table 2). As mentioned above, location and side effects were not evident with the sonar data. Still, it should be emphasized that the temporal variability in sonar counts was quite high (Section 3.1). Further research will be required to determine if this trend continues.

The gill net data gave a more accurate assessment of fish species that the sonar data. Fish collected in the nets could be identified, aged and weighed. At present, the sonar data cannot speciate and probably never will have the ability to age fish. The Darlington data still have not yet been subjected to a pattern recognition system such as neural networks for species classification. Preliminary work conducted on other species (sturgeon, rainbow trout, walleye) in the laboratory suggest that this technique shows

merit in classifying fish targets (Ramani et al. 1990). Other researchers have had success in classifying sonar signals (eg, Rose and Leggett 1988).

### 3.6 Remote Transmission of Data

Perhaps one of the major advantages of a sonar system over sampling techniques is that sonar data can be collected automatically and transmitted from the field to the laboratory or office as a cost saving measure. During the July sampling period, the feasibility of remote data transmission was demonstrated. Transmission using modems occurred from the boat (at Darlington NGS) to both Head Office (ES&A) and Research. This was the first example of remote transmission in an aquatic biological program. Future studies are proposed which will allow more continuous data transmission by using a sonar buoy (Appendix A).

### 3.7 Low Frequency Sound Experiments

Preliminary experiments were conducted in the laboratory and field to determine the feasibility of insertion loss for detecting and classifying fish. Laboratory data with bubble packing material indicated an insertion loss (Figure 18). This was consistent with that reported earlier in the lab (OHRDR 90-25-H). An insertion loss was not demonstrated in the field because of technical difficulties (electrical interference). However, the "control" or baseline data (Figure 19) did indicate less variability will occur in the field compared to the lab (Figure 18). A measurable effect may therefore be easier to see in the field than in the lab as suggested by Jennette 1990.

### 3.8 Interpretive Analysis

The results suggest high effectiveness of the veneer intake under low flow conditions (only one unit was operating near capacity). Large number of alewife encounters were observed especially during July (Figure 5), yet impingement was minimal (Table 1). However, it should be emphasized that intake flow rates were low (below 49 m3/s) throughout the sampling period, and additional information on the encounters/impingement ratio will be required under higher flow regimes. During 1991, it is expected that two units will be operating and additional experiments are proposed. In addition, it is not known how long fish reside in the forebay prior to impingement. Last year small numbers of fish (emerald shiners, alewife, smelt) were observed in the forebay (Harcus 1990).

There was also no evidence of an attraction to the porous sections of the veneer during both June and July (Table 2). These data are preliminary, and should be repeated with higher intake velocities. A preference for the porous sections could result in fish spending more time in the vicinity of the open ports and possibly higher impingement.

The use of sonar is considered an appropriate technique for collecting information on fish encounters of the veneer surface. Continuous reliable data can be collected over a large distance interval (40 m in this study) in different directions using several transducers. No significant difference in mean echoes was observed among transducers either placed side-by-side or at

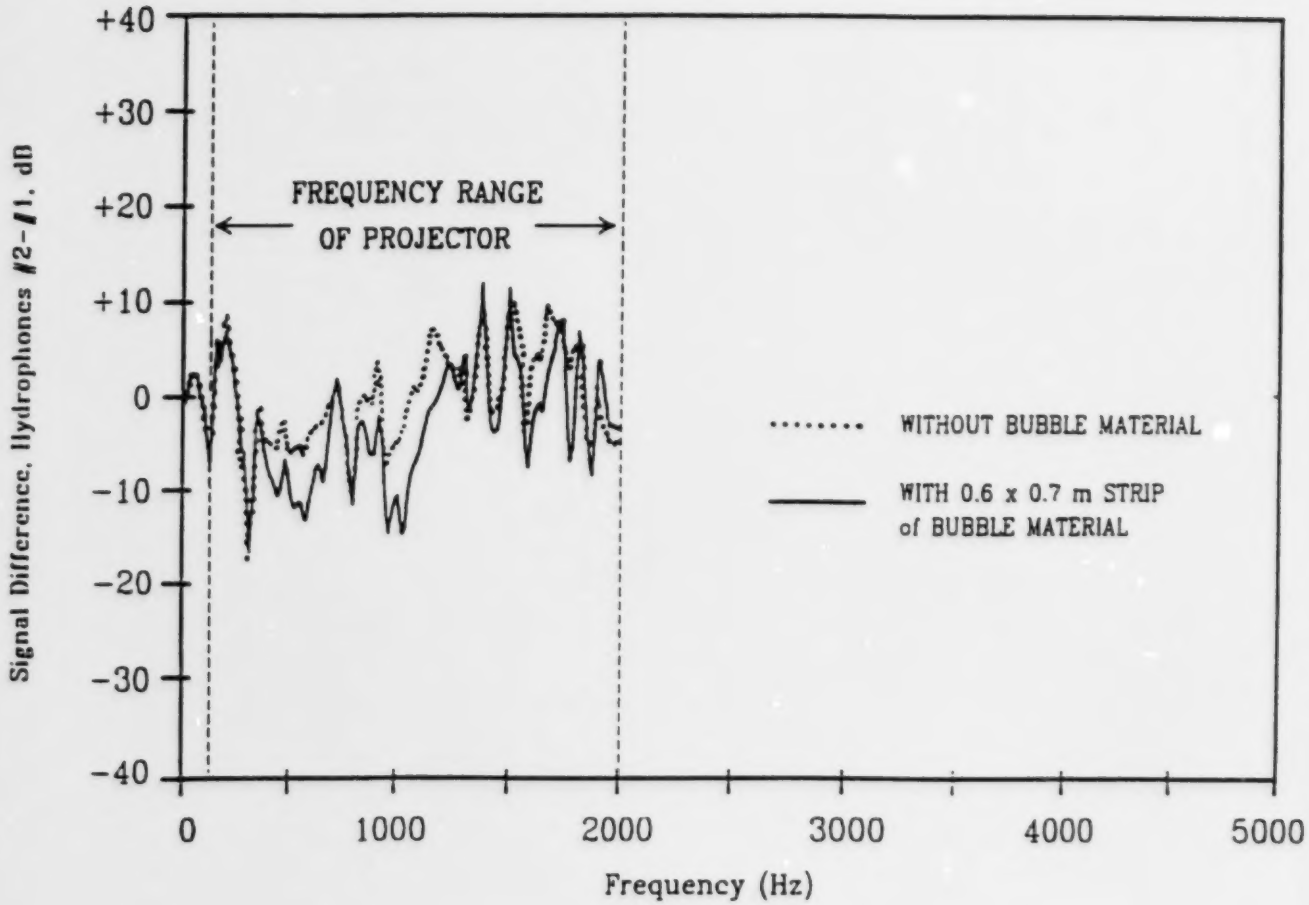



FIGURE 18

APPROXIMATE INSERTION LOSS PRODUCED
BY BUBBLE MATERIAL IN BLDG. KV TANK - JUNE 12, 1990

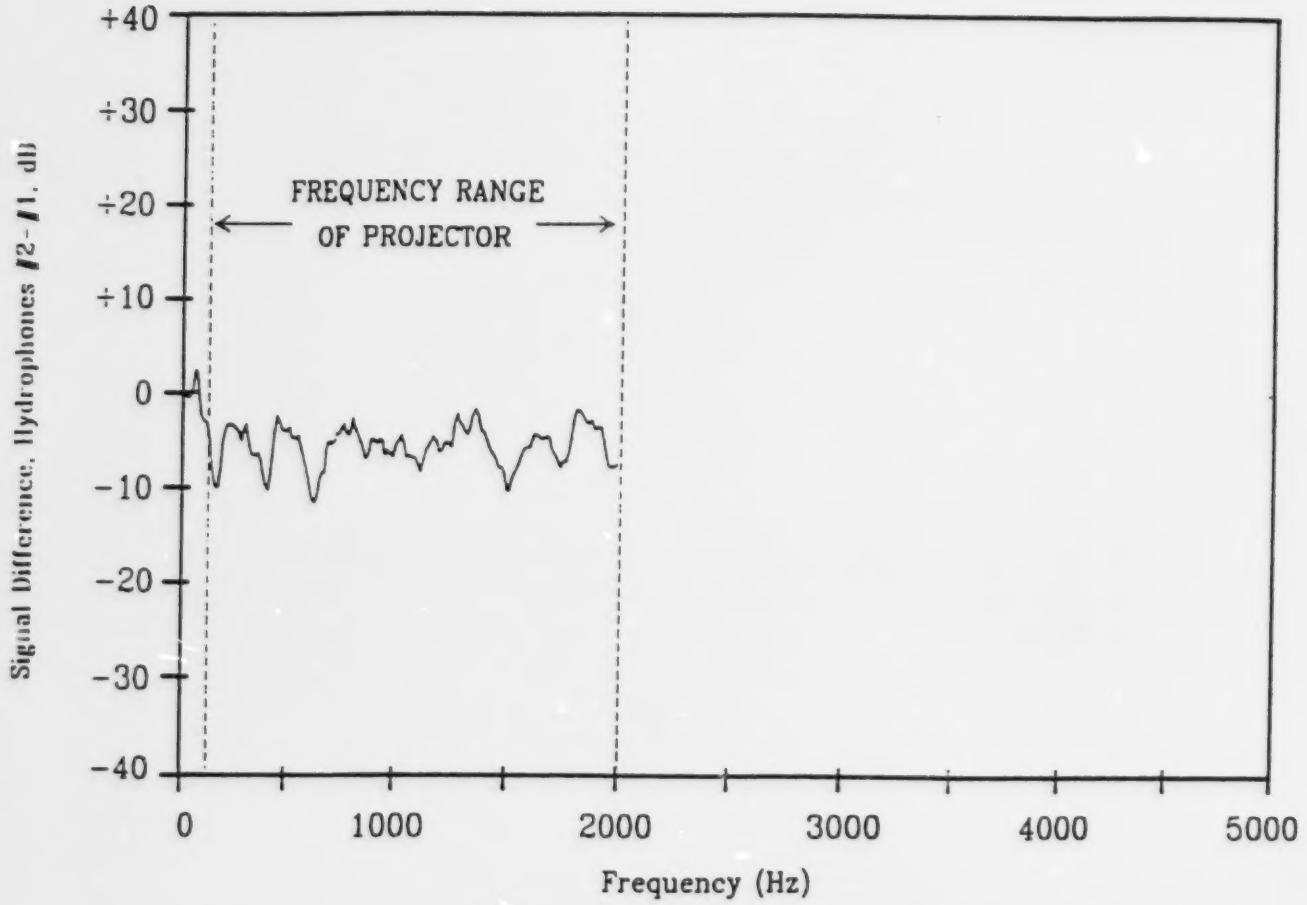



FIGURE 19

INSERTION LOSS TEST - J13 ON, NO FISH
DARLINGTON NGS INTAKE - JUNE 13, 1990

different locations. High temporal variability did occur which was related to the offshore-onshore movement of fish and/or diurnal behavioural differences. Sonar has the distinct advantage over other sampling techniques in that it can take into account fish movement at different times of the day and at different locations (porous vs non-porous). Another advantage of is that is amenable to automatic collection and processing, and remote transmission, and therefore can be an extremely cost-effective approach. Labour costs are an important component of present aquatic work because of safety requirements (eg. work on the Great Lakes requires several staff members even if routine sampling such as netting is required). A major shortcoming of sonar is the ability to speciate the targets. Although methodologies are being developed to classify targets, it is probable that netting will always be required to verify the species being observed by sonar. For future Darlington work, the routine monitoring (netting) as part of the Effects Program could also be used to supplement the sonar information.

It is possible that other systems such as high resolution cameras could be used with sonar to determine performance of the veneer. This may not necessary since information on both encounters (using sonar and netting) and impingement alone can give an accurate assessment of effectiveness. Furthermore, systems such as cameras are generally only effective in collecting information during the day when fish activity may be lowest. Most impingement (fish activity) tends to occur at night or early evening (eg. Pickering NGS, McKinley and Patrick 1989). Cameras used at night will require some artificial illumination which will probably attract fish species such as alewife which would influence results (Patrick and Vascotto 1981, Haymes et al. 1984).

## 4.0 ACKNOWLEDGMENTS

Several individuals contributed significantly to this project. Scott Poulton did a superb job in setting up the sonar equipment and data analysis, and was extremely valuable to this project. Tricia Mooney, Jim Harcus and Brenda Jeppesen also assisted in data analysis. Jim Harcus and Ed Ckecko were especially valuable during set-up. Other crew members Blair Sim, Doug Parker, Mike McKay and Cindy Mitton are also acknowledged. The insertion experiments were performed primarily by John Kowalewski, Alex Sukota and Mike Colbert of Mechanical Research. The software program for cone volume correction (sonar data) was done by Ron Ing of Operations Research. Statistical analysis of the data was done by Alison Burnham of Operations Research.

## 5.0 SUMMARY

1. Investigations were conducted on the use of sonar coupled with impingement records in determining the effectiveness of the Darlington porous veneer in excluding fish. Continuous acoustic sampling was conducted June 12-14, July 23-25, and October 16-17 to assess the number of fish encounters and fish behaviour above both porous and non-porous sections of the veneer. Continuously recorded sonar data were collected during both day and night periods using four transducers multiplexed at regular intervals. Paired gill nets were also set to the east and west of the veneer, and were compared to the sonar data.

2. Few fish were impinged during each sampling period. The number of fish encounters based on sonar data was highest in July followed by June and October. The gill net data showed the same trend. The principle species collected was alewife. Several thousand fish echoes were noted in July yet impingement was negligible suggesting high effectiveness. Similarly, in June and October, when fish numbers were lower, there were few fish impinged relative to the number of encounters. Still, these results are preliminary since intake flows were low averaging less than 50 m3/s for each sampling period (ie. one unit operation).

3. There was no evidence that fish preferred or were attracted to the porous sections of the veneer relative to the non-porous ones.

4. Remote transmission of data from the field to the laboratory as a cost-effective means of collecting and analyzing data was demonstrated.

5. Future research is proposed to determine effectiveness of the veneer when two or more units at Darlington are operating.

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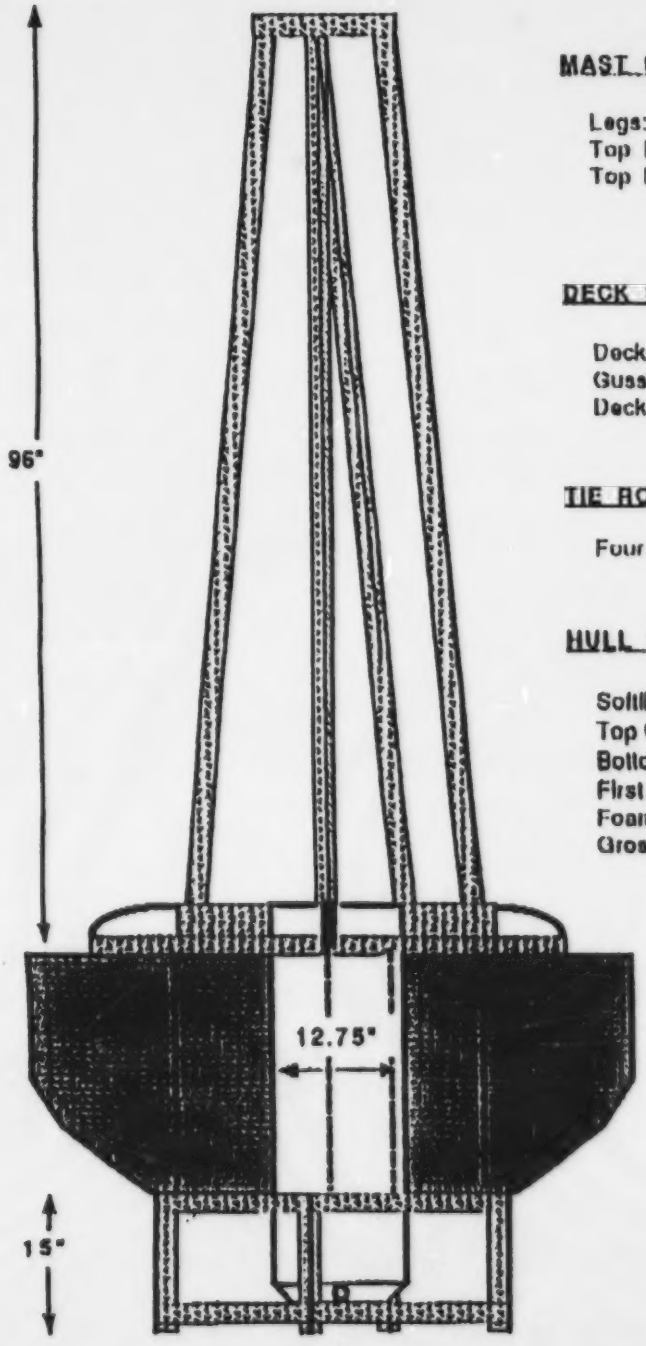
# Appendix A

## ONTARIO HYDRO SEMI HEMI BUOY




**MAST SPECIFICATIONS**

Legs: 2" x 2" x 1/4" 6061 T-6 Aluminum
Top Plate: 1/4" 6061 T-6 Aluminum
Top Ring: 2" x 2" x1/4" 6061 T-6 Aluminum

**DECK SPECIFICATIONS**

Deck Ring & Spokes: 2" x 2" x 1/4" Galvanized Steel
Gusset Plates: 1/2" Galvanized Steel
Deck Lifting Bails: 3/4" Galvanized Steel

**TIE ROD SPECIFICATIONS**

Four 1/2" 316 Stainless Steel

**HULL SPECIFICATIONS**

Solifite Foam: 4.5 PCF
Top O.D.: 60"
Bottom O. D.: 36"
First cut at: 13"
Foam Body Weight: 165 Lbs
Gross Hull Displacement: 2200 Lbs

**BOTTOM SPECIFICATIONS**

Base Unit: All 2" x 2" x1/4" Galvanized Steel
Handling Eyes: 1/2" Galvanized Steel

**WELL SPECIFICATIONS**

Well Tube: 1/4" Galvanized Steel
Well Flange: 3/8" Galvanized Steel
Well Cover: 3/8" Galvanized Steel
Mooring Attachment Bail: 1" Galvanized Steel

# APPENDIX B

[JUNE] ADJUSTED COUNTS (Transducer #1)

| TIME | 6-11m | 11-16m | 16-21m | 21-26m | 26-30m | 30-35m | 35-40m | 6-21m | 21-40m | 6-40m |
|---|---|---|---|---|---|---|---|---|---|---|
| 23:00 | 0 | 25 | 20 | 16 | 25 | 11 | 47 | 45 | 99 | 144 |
| 00:04 | 0 | 12 | 13 | 20 | 0 | 2 | 2 | 25 | 24 | 49 |
| 01:08 | 91 | 74 | 26 | 12 | 4 | 6 | 10 | 191 | 32 | 223 |
| 02:44 | 0 | 25 | 52 | 37 | 58 | 19 | 0 | 77 | 114 | 191 |
| 03:55 | 0 | 37 | 0 | 4 | 4 | 13 | 338 | 37 | 359 | 396 |
| 04:51 | 30 | 0 | 0 | 12 | 11 | 4 | 5 | 30 | 32 | 62 |
| 07:31 | 0 | 0 | 13 | 12 | 0 | 0 | 0 | 13 | 12 | 25 |
| 08:18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 09:24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10:24 | 0 | 147 | 20 | 0 | 0 | 0 | 0 | 167 | 0 | 167 |

n ====> 10

| | 6-21m | 21-40m | 6-40m |
|---|---|---|---|
| Mean: | 58.50 | 67.20 | 125.70 |
| Std.Dev.: | 64.16 | 104.54 | 118.54 |

[JUNE] ADJUSTED COUNTS (Transducer #2)

| TIME | 6-11m | 11-16m | 16-21m | 21-26m | 26-30m | 30-35m | 35-40m | 6-26m | 26-40m | 6-40m |
|---|---|---|---|---|---|---|---|---|---|---|
| 23:08 | 30 | 12 | 0 | 8 | 0 | 0 | 0 | 50 | 0 | 50 |
| 00:12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 01:16 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 12 |
| 04:03 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 3 | 3 |
| 09:28 | 0 | 0 | 13 | 65 | 108 | 36 | 2 | 78 | 146 | 224 |
| 10:40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19:15 | 0 | 0 | 0 | 0 | 4 | 2 | 0 | 0 | 6 | 6 |
| 19:47 | 122 | 159 | 0 | 49 | 61 | 62 | 6 | 330 | 129 | 459 |
| 20:50 | 122 | 0 | 0 | 0 | 14 | 68 | 95 | 122 | 177 | 299 |
| 21:54 | 61 | 25 | 13 | 16 | 14 | 21 | 19 | 115 | 54 | 169 |
| 22:58 | 0 | 12 | 0 | 0 | 0 | 0 | 6 | 12 | 6 | 18 |
| 00:02 | 0 | 0 | 20 | 4 | 11 | 6 | 10 | 24 | 27 | 51 |
| 01:06 | 30 | 0 | 0 | 4 | 11 | 11 | 3 | 34 | 25 | 59 |
| 02:27 | 152 | 0 | 0 | 4 | 4 | 0 | 0 | 156 | 4 | 160 |
| 04:00 | 0 | 0 | 7 | 0 | 0 | 4 | 0 | 7 | 4 | 11 |
| 04:32 | 0 | 12 | 0 | 8 | 4 | 0 | 0 | 20 | 4 | 24 |
| 05:36 | 0 | 0 | 0 | 0 | 4 | 4 | 0 | 0 | 8 | 8 |
| 06:19 | 0 | 0 | 0 | 0 | 14 | 2 | 0 | 0 | 16 | 16 |
| 09:11 | 0 | 0 | 20 | 0 | 0 | 0 | 0 | 20 | 0 | 20 |
| 10:15 | 0 | 37 | 0 | 0 | 7 | 4 | 10 | 37 | 21 | 58 |
| 11:59 | 0 | 0 | 0 | 0 | 0 | 4 | 5 | 0 | 9 | 9 |
| 12:31 | 0 | 0 | 0 | 0 | 0 | 23 | 16 | 0 | 39 | 39 |

n ====> 22

| | 6-26m | 26-40m | 6-40m |
|---|---|---|---|
| Mean: | 46.23 | 30.82 | 77.05 |
| Std.Dev.: | 76.02 | 50.07 | 114.67 |

[JUNE] ADJUSTED COUNTS (Transducer #4)

| TIME | 6-11m | 11-16m | 16-21m | 21-26m | 26-30m | 30-35m | 35-40m | 6-26m | 26-40m | 6-40m |
|---|---|---|---|---|---|---|---|---|---|---|
| 23:24 | 30 | 49 | 7 | 12 | 0 | 2 | 0 | 98 | 2 | 100 |
| 00:28 | 30 | 0 | 0 | 4 | 0 | 2 | 3 | 34 | 5 | 39 |
| 01:32 | 30 | 0 | 0 | 0 | 0 | 0 | 2 | 30 | 2 | 32 |
| 03:08 | 182 | 0 | 7 | 0 | 0 | 19 | 127 | 189 | 146 | 335 |
| 09:44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12:00 | 0 | 0 | 0 | 12 | 7 | 0 | 0 | 12 | 7 | 19 |
| 19:31 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 3 | 3 |
| 20:03 | 516 | 502 | 197 | 167 | 36 | 0 | 3 | 1382 | 39 | 1421 |
| 21:05 | 0 | 12 | 0 | 0 | 0 | 90 | 122 | 12 | 212 | 224 |
| 22:10 | 30 | 331 | 20 | 20 | 18 | 23 | 13 | 401 | 54 | 455 |
| 23:14 | 0 | 86 | 13 | 0 | 4 | 6 | 13 | 99 | 23 | 122 |
| 00:18 | 30 | 625 | 0 | 4 | 4 | 2 | 3 | 659 | 9 | 668 |
| 01:22 | 30 | 0 | 33 | 4 | 4 | 4 | 5 | 67 | 13 | 80 |
| 02:43 | 30 | 12 | 7 | 4 | 4 | 0 | 0 | 53 | 4 | 57 |
| 03:36 | 30 | 25 | 0 | 4 | 7 | 4 | 0 | 59 | 11 | 70 |
| 04:08 | 0 | 0 | 7 | 0 | 0 | 0 | 5 | 7 | 5 | 12 |
| 04:40 | 0 | 0 | 0 | 4 | 0 | 0 | 2 | 4 | 2 | 6 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 05:12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 05:44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 06:27 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 07:09 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 09:27 | 0 | 0 | 0 | 0 | 0 | 0 | 26 | 0 | 26 | 26 |

n ====> 22

| | 6-26m | 26-40m | 6-40m |
|---|---|---|---|
| Mean: | 141.18 | 25.59 | 166.77 |
| Std.Dev.: | 311.51 | 51.35 | 320.95 |

Transducers #2 and #4

n ====> 54

| | 6-26m | 26-40m | 6-40m |
|---|---|---|---|
| Mean: | 93.70 | 28.20 | 121.91 |
| Std.Dev.: | 231.65 | 50.78 | 245.14 |

| [JULY] TIME | ADJUSTED COUNTS (Transducer #1) 6-11m | 11-16m | 16-21m | 21-26m | 26-30m | 30-35m | 35-40m | 6-21m | 21-40m | 6-40m |
|---|---|---|---|---|---|---|---|---|---|---|
| 21:48 | 61 | 110 | 118 | 114 | 147 | 186 | 192 | 289 | 639 | 928 |
| 22:20 | 0 | 49 | 0 | 163 | 47 | 126 | 164 | 49 | 500 | 549 |
| 22:52 | 0 | 0 | 20 | 33 | 119 | 271 | 269 | 20 | 692 | 712 |
| 23:24 | 30 | 0 | 33 | 179 | 183 | 352 | 327 | 63 | 1041 | 1104 |
| 23:56 | 0 | 0 | 20 | 261 | 460 | 399 | 282 | 20 | 1402 | 1422 |
| 00:28 | 0 | 0 | 79 | 183 | 873 | 390 | 266 | 79 | 1712 | 1791 |
| 01:00 | 0 | 12 | 33 | 277 | 949 | 796 | 876 | 45 | 2898 | 2943 |
| 01:32 | 0 | 37 | 269 | 277 | 733 | 702 | 630 | 306 | 2342 | 2648 |
| 02:04 | 30 | 49 | 39 | 322 | 474 | 346 | 361 | 118 | 1503 | 1621 |
| 02:36 | 182 | 74 | 39 | 98 | 457 | 292 | 459 | 295 | 1306 | 1601 |
| 03:08 | 152 | 110 | 111 | 293 | 572 | 523 | 484 | 373 | 1872 | 2245 |
| 03:40 | 760 | 110 | 230 | 261 | 309 | 245 | 362 | 1100 | 1177 | 2277 |
| 05:15 | 0 | 0 | 66 | 24 | 22 | 9 | 50 | 66 | 105 | 171 |
| 05:48 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 4 | 4 |
| 06:51 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 25 |
| 08:21 | 0 | 0 | 0 | 0 | 50 | 2 | 93 | 0 | 145 | 145 |
| 08:46 | 0 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 12 | 12 |
| 09:46 | 0 | 0 | 0 | 0 | 0 | 9 | 55 | 0 | 64 | 64 |
| 10:17 | 30 | 135 | 144 | 338 | 410 | 427 | 300 | 309 | 1475 | 1784 |
| 10:50 | 0 | 0 | 0 | 4 | 22 | 0 | 5 | 0 | 31 | 31 |
| 11:21 | 30 | 0 | 0 | 0 | 18 | 70 | 2 | 30 | 90 | 120 |
| 12:25 | 0 | 0 | 0 | 0 | 0 | 6 | 5 | 0 | 11 | 11 |
| 12:57 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13:29 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 4 | 4 |
| 14:01 | 0 | 0 | 0 | 0 | 0 | 58 | 80 | 0 | 138 | 138 |
| 14:33 | 5651 | 6162 | 1017 | 0 | 0 | 0 | 0 | 2830 | 0 | 12830 |
| 15:05 | 273 | 3161 | 1731 | 998 | 392 | 2 | 0 | 5165 | 1392 | 6557 |
| 15:37 | 0 | 0 | 105 | 0 | 32 | 2 | 91 | 105 | 125 | 230 |
| 16:41 | 0 | 0 | 0 | 0 | 14 | 11 | 0 | 0 | 25 | 25 |
| 17:13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17:45 | 304 | 159 | 46 | 0 | 32 | 30 | 199 | 509 | 261 | 770 |
| 18:17 | 1823 | 0 | 0 | 0 | 0 | 2 | 0 | 1823 | 2 | 1825 |
| 16:09 | 0 | 74 | 52 | 0 | 0 | 0 | 3 | 126 | 3 | 129 |
| 18:48 | 1884 | 86 | 2125 | 982 | 431 | 47 | 101 | 4095 | 1561 | 5656 |
| 19:20 | 61 | 37 | 256 | 4 | 0 | 4 | 2 | 354 | 10 | 364 |
| 21:24 | 0 | 25 | 131 | 293 | 989 | 1082 | 1461 | 156 | 3825 | 3981 |
| 21:52 | 608 | 294 | 177 | 1096 | 5237 | 4421 | 3414 | 1079 | 14168 | 15247 |
| 22:24 | 668 | 245 | 59 | 354 | 3264 | 3423 | 2614 | 972 | 9655 | 10627 |
| 22:56 | 3463 | 1335 | 623 | 876 | 3677 | 3489 | 2556 | 5421 | 10598 | 16019 |
| 23:28 | 2582 | 735 | 328 | 196 | 539 | 730 | 569 | 3645 | 2034 | 5679 |
| 00:00 | 122 | 233 | 210 | 265 | 431 | 376 | 377 | 565 | 1449 | 2014 |
| 00:32 | 30 | 0 | 39 | 147 | 536 | 672 | 473 | 69 | 1828 | 1897 |
| 01:04 | 30 | 25 | 308 | 139 | 421 | 824 | 579 | 363 | 1963 | 2326 |
| 01:35 | 61 | 110 | 125 | 69 | 234 | 173 | 196 | 296 | 672 | 968 |
| 02:07 | 152 | 110 | 177 | 65 | 108 | 152 | 119 | 439 | 444 | 883 |
| 03:07 | 334 | 392 | 289 | 363 | 176 | 248 | 165 | 1015 | 952 | 1967 |
| 03:39 | 1154 | 294 | 157 | 106 | 140 | 124 | 361 | 1605 | 731 | 2336 |
| 04:11 | 365 | 931 | 721 | 1389 | 5208 | 2996 | 1993 | 2017 | 11586 | 13603 |
| 04:43 | 273 | 343 | 656 | 269 | 1621 | 807 | 558 | 1272 | 3255 | 4527 |
| 05:15 | 0 | 25 | 20 | 24 | 58 | 188 | 120 | 45 | 390 | 435 |
| 05:47 | 0 | 0 | 0 | 4 | 0 | 175 | 167 | 0 | 346 | 346 |
| 06:19 | 0 | 0 | 0 | 12 | 669 | 640 | 394 | 0 | 1715 | 1715 |
| 06:51 | 0 | 37 | 13 | 4 | 1017 | 307 | 18 | 50 | 1346 | 1396 |
| 07:23 | 0 | 0 | 0 | 61 | 230 | 0 | 3 | 0 | 294 | 294 |
| 07:55 | 0 | 0 | 138 | 1300 | 1380 | 726 | 608 | 138 | 4014 | 4152 |
| 08:27 | 0 | 0 | 0 | 0 | 4 | 6 | 2 | 0 | 12 | 12 |
| 08:58 | 0 | 0 | 0 | 0 | 18 | 15 | 8 | 0 | 41 | 41 |
| 09:30 | 0 | 0 | 0 | 0 | 43 | 13 | 47 | 0 | 103 | 103 |
| 10:02 | 304 | 0 | 0 | 33 | 68 | 62 | 35 | 304 | 198 | 502 |
| 10:34 | 152 | 0 | 0 | 33 | 173 | 70 | 29 | 152 | 305 | 457 |
| 11:05 | 304 | 0 | 20 | 81 | 536 | 220 | 82 | 324 | 919 | 1243 |
| 11:37 | 0 | 0 | 0 | 469 | 2009 | 824 | 220 | 0 | 3522 | 3522 |
| 12:17 | 0 | 0 | 7 | 469 | 2901 | 1780 | 677 | 466 | 1309 | 5834 |
| 12:49 | 0 | 0 | 7 | 4151 | 7347 | 4522 | 2736 | 1316 | 1367 | 18763 |
| 13:21 | 0 | 0 | 0 | 876 | 3267 | 2454 | 1039 | 722 | 1353 | 7636 |
| 14:13 | 0 | 0 | 52 | 0 | 14 | 0 | 3 | 79 | 527 | 69 |
| 14:41 | 0 | 551 | 695 | 273 | 1499 | 1912 | 919 | 606 | 1288 | 5849 |
| 15:13 | 0 | 0 | 439 | 2061 | 3300 | 2471 | 1830 | 1445 | 1432 | 10101 |
| 15:45 | 0 | 0 | 0 | 102 | 532 | 378 | 146 | 215 | 1040 | 1158 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 16:17 | 0 | 0 | 0 | 0 | 7 | 4 | 0 | 0 | 32 | 11 |
| 16:49 | 0 | 0 | 0 | 0 | 0 | 9 | 3 | 0 | 19 | 12 |
| 17:02 | 0 | 0 | 0 | 0 | 0 | 6 | 2 | 6 | 19 | 8 |
| 17:31 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 8 | 7 |
| 18:04 | 0 | 0 | 0 | 4 | 11 | 51 | 6 | 82 | 692 | 72 |
| 18:34 | 61 | 0 | 0 | 0 | 7 | 36 | 11 | 29 | 678 | 115 |

n ====> 75

| | 6-21m | 21-40m | 6-40m |
|---|---|---|---|
| Mean: | 665.77 | 1956.40 | 2622.17 |
| Std.Dev.: | 1778.09 | 3512.46 | 4113.74 |

[JULY] ADJUSTED COUNTS (Transducer #2)

| TIME | 6-11m | 11-16m | 16-21m | 21-26m | 26-30m | 30-35m | 35-40m | 6-26m | 26-40m | 6-40m |
|---|---|---|---|---|---|---|---|---|---|---|
| 21:56 | 0 | 0 | 0 | 16 | 230 | 211 | 111 | 16 | 552 | 568 |
| 22:28 | 0 | 0 | 13 | 12 | 93 | 19 | 34 | 25 | 146 | 171 |
| 23:00 | 61 | 0 | 0 | 0 | 86 | 15 | 30 | 61 | 131 | 192 |
| 23:32 | 0 | 0 | 0 | 4 | 14 | 9 | 53 | 4 | 76 | 80 |
| 00:04 | 30 | 0 | 13 | 4 | 22 | 26 | 6 | 47 | 54 | 101 |
| 00:36 | 0 | 37 | 7 | 29 | 14 | 41 | 26 | 73 | 81 | 154 |
| 01:08 | 213 | 12 | 7 | 16 | 50 | 34 | 74 | 248 | 158 | 406 |
| 01:40 | 30 | 25 | 7 | 0 | 122 | 41 | 119 | 62 | 282 | 344 |
| 02:12 | 30 | 49 | 39 | 12 | 11 | 41 | 24 | 130 | 76 | 206 |
| 02:44 | 334 | 294 | 85 | 106 | 101 | 26 | 29 | 819 | 156 | 975 |
| 03:15 | 365 | 172 | 420 | 191 | 590 | 600 | 204 | 1148 | 1394 | 2542 |
| 03:48 | 0 | 37 | 20 | 16 | 4 | 11 | 0 | 73 | 15 | 88 |
| 05:32 | 0 | 25 | 7 | 0 | 7 | 2 | 30 | 32 | 39 | 71 |
| 05:56 | 30 | 0 | 0 | 0 | 0 | 0 | 5 | 30 | 5 | 35 |
| 06:27 | 0 | 0 | 0 | 0 | 4 | 11 | 0 | 0 | 15 | 15 |
| 07:57 | 0 | 0 | 13 | 0 | 0 | 0 | 30 | 13 | 30 | 43 |
| 08:50 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 13 | 13 |
| 09:22 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 2 | 2 |
| 09:54 | 334 | 221 | 230 | 660 | 320 | 15 | 21 | 1445 | 356 | 1801 |
| 10:25 | 1458 | 466 | 20 | 45 | 14 | 58 | 107 | 1989 | 179 | 2168 |
| 10:58 | 4375 | 0 | 0 | 0 | 0 | 17 | 55 | 4375 | 72 | 4447 |
| 11:29 | 7322 | 1703 | 223 | 41 | 0 | 4 | 14 | 9289 | 18 | 9307 |
| 12:01 | 5226 | 0 | 0 | 0 | 0 | 2 | 8 | 5226 | 10 | 5236 |
| 12:33 | 5165 | 0 | 0 | 0 | 0 | 9 | 11 | 5165 | 20 | 5185 |
| 13:05 | 7048 | 282 | 0 | 0 | 0 | 17 | 22 | 7330 | 39 | 7369 |
| 13:37 | 4101 | 221 | 33 | 0 | 11 | 0 | 3 | 4355 | 14 | 4369 |
| 14:09 | 14006 | 2119 | 46 | 0 | 0 | 9 | 11 | 16171 | 20 | 16191 |
| 14:41 | 11454 | 3149 | 85 | 0 | 0 | 0 | 18 | 14688 | 18 | 14706 |
| 15:13 | 17287 | 7620 | 1003 | 98 | 7 | 73 | 186 | 26008 | 266 | 26274 |
| 15:45 | 10664 | 2904 | 20 | 24 | 187 | 248 | 24 | 13612 | 459 | 14071 |
| 16:17 | 760 | 245 | 0 | 0 | 7 | 0 | 5 | 1005 | 12 | 1017 |
| 16:49 | 0 | 196 | 420 | 171 | 79 | 21 | 3 | 787 | 103 | 890 |
| 17:21 | 699 | 306 | 7 | 0 | 14 | 11 | 47 | 1012 | 72 | 1084 |
| 17:53 | 12183 | 9752 | 630 | 0 | 4 | 119 | 194 | 22565 | 317 | 22882 |
| 18:25 | 13337 | 6432 | 1449 | 57 | 0 | 6 | 6 | 21275 | 12 | 21287 |
| 18:56 | 11241 | 7045 | 3463 | 126 | 4 | 0 | 2 | 21875 | 6 | 21881 |
| 19:28 | 6562 | 3479 | 426 | 147 | 205 | 177 | 29 | 10614 | 411 | 11025 |
| 21:28 | 304 | 245 | 216 | 240 | 201 | 141 | 66 | 1005 | 408 | 1413 |
| 22:00 | 1489 | 919 | 466 | 318 | 255 | 177 | 111 | 3192 | 543 | 3735 |
| 22:32 | 881 | 392 | 275 | 208 | 230 | 122 | 50 | 1756 | 402 | 2158 |
| 23:04 | 668 | 368 | 367 | 265 | 165 | 73 | 79 | 1668 | 317 | 1985 |
| 23:36 | 1094 | 760 | 453 | 285 | 324 | 143 | 104 | 2592 | 571 | 3163 |
| 00:08 | 608 | 221 | 92 | 102 | 165 | 49 | 43 | 1023 | 257 | 1280 |
| 00:40 | 91 | 74 | 72 | 73 | 126 | 109 | 119 | 310 | 354 | 664 |
| 01:12 | 0 | 37 | 39 | 139 | 273 | 102 | 159 | 215 | 534 | 749 |
| 01:43 | 61 | 61 | 39 | 126 | 226 | 122 | 250 | 287 | 598 | 885 |
| 02:15 | 213 | 49 | 105 | 179 | 579 | 314 | 197 | 546 | 1090 | 1636 |
| 03:15 | 942 | 380 | 190 | 269 | 410 | 224 | 197 | 1781 | 831 | 2612 |
| 03:47 | 668 | 282 | 190 | 167 | 255 | 277 | 268 | 1307 | 800 | 2107 |
| 04:19 | 91 | 12 | 144 | 228 | 183 | 333 | 220 | 475 | 736 | 1211 |
| 04:51 | 182 | 270 | 144 | 94 | 180 | 282 | 337 | 690 | 799 | 1489 |
| 05:23 | 61 | 12 | 33 | 41 | 25 | 28 | 99 | 147 | 152 | 299 |
| 05:55 | 0 | 0 | 7 | 0 | 0 | 0 | 22 | 7 | 22 | 29 |
| 06:27 | 1944 | 735 | 0 | 0 | 0 | 0 | 0 | 2679 | 0 | 2679 |
| 06:59 | 760 | 845 | 492 | 73 | 25 | 2 | 2 | 2170 | 29 | 2199 |
| 07:31 | 1549 | 735 | 85 | 0 | 0 | 0 | 0 | 2369 | 0 | 2369 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 08:03 | 365 | 61 | 0 | 0 | 0 | 6 | 0 | 426 | 6 | 432 |
| 08:35 | 365 | 0 | 0 | 0 | 14 | 271 | 6 | 365 | 291 | 656 |
| 09:06 | 0 | 0 | 20 | 110 | 7 | 0 | 3 | 130 | 10 | 140 |
| 09:38 | 61 | 0 | 0 | 0 | 0 | 0 | 0 | 61 | 0 | 61 |
| 10:10 | 243 | 159 | 7 | 0 | 0 | 0 | 0 | 409 | 0 | 409 |
| 10:42 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 5 | 5 |
| 11:13 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 4 | 4 |
| 11:45 | 0 | 0 | 0 | 204 | 978 | 414 | 131 | 204 | 1523 | 1727 |
| 12:25 | 0 | 0 | 0 | 37 | 536 | 431 | 390 | 37 | 1357 | 1394 |
| 12:57 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 4 | 4 |
| 13:29 | 0 | 0 | 0 | 0 | 0 | 9 | 3 | 0 | 12 | 12 |
| 14:17 | 0 | 0 | 0 | 0 | 0 | 9 | 51 | 0 | 60 | 60 |
| 14:49 | 0 | 0 | 13 | 139 | 14 | 224 | 42 | 152 | 280 | 432 |
| 15:21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15:53 | 0 | 0 | 0 | 0 | 72 | 49 | 0 | 0 | 121 | 121 |
| 16:25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17:07 | 0 | 0 | 7 | 8 | 0 | 0 | 0 | 15 | 0 | 15 |
| 17:39 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18:10 | 0 | 0 | 0 | 0 | 0 | 9 | 13 | 0 | 22 | 22 |
| 18:42 | 0 | 0 | 0 | 61 | 288 | 269 | 176 | 61 | 733 | 794 |

n ====> 76

| | 6-26m | 26-40m | 6-40m |
|---|---|---|---|
| Mean: | 2863.76 | 243.42 | 3107.18 |
| Std.Dev.: | 5804.44 | 347.12 | 5784.65 |

[JULY] ADJUSTED COUNTS (Transducer #3)

| TIME | 6-11m | 11-16m | 16-21m | 21-26m | 26-30m | 30-35m | 35-40m | 6-21m | 21-40m | 6-40m |
|---|---|---|---|---|---|---|---|---|---|---|
| 22:04 | 0 | 0 | 0 | 29 | 7 | 4 | 87 | 0 | 127 | 127 |
| 22:36 | 0 | 0 | 33 | 0 | 11 | 73 | 181 | 33 | 265 | 298 |
| 23:08 | 0 | 0 | 7 | 16 | 22 | 62 | 135 | 7 | 235 | 242 |
| 23:40 | 0 | 12 | 0 | 0 | 0 | 2 | 64 | 12 | 66 | 78 |
| 00:12 | 30 | 25 | 33 | 77 | 7 | 2 | 30 | 88 | 116 | 204 |
| 00:44 | 0 | 0 | 7 | 4 | 14 | 15 | 99 | 7 | 132 | 139 |
| 01:16 | 30 | 0 | 0 | 4 | 50 | 43 | 66 | 30 | 163 | 193 |
| 01:49 | 0 | 0 | 13 | 24 | 7 | 2 | 71 | 13 | 104 | 117 |
| 02:20 | 30 | 25 | 66 | 49 | 18 | 15 | 21 | 121 | 103 | 224 |
| 02:52 | 122 | 49 | 59 | 49 | 11 | 17 | 22 | 230 | 99 | 329 |
| 03:24 | 608 | 123 | 92 | 163 | 119 | 102 | 75 | 823 | 459 | 1282 |
| 03:55 | 91 | 282 | 269 | 61 | 183 | 21 | 48 | 642 | 313 | 955 |
| 05:31 | 0 | 37 | 7 | 41 | 14 | 19 | 183 | 44 | 257 | 301 |
| 06:03 | 0 | 0 | 0 | 12 | 22 | 6 | 50 | 0 | 90 | 90 |
| 06:35 | 0 | 0 | 0 | 0 | 0 | 9 | 130 | 0 | 139 | 139 |
| 07:07 | 0 | 0 | 0 | 0 | 0 | 11 | 130 | 0 | 141 | 141 |
| 08:04 | 0 | 0 | 0 | 24 | 0 | 2 | 148 | 0 | 174 | 174 |
| 08:58 | 0 | 0 | 0 | 0 | 0 | 0 | 34 | 0 | 34 | 34 |
| 09:30 | 0 | 0 | 33 | 12 | 4 | 122 | 119 | 33 | 257 | 290 |
| 10:01 | 0 | 0 | 203 | 236 | 83 | 132 | 216 | 203 | 667 | 870 |
| 10:33 | 0 | 0 | 20 | 8 | 0 | 0 | 98 | 20 | 106 | 126 |
| 11:05 | 0 | 0 | 0 | 29 | 32 | 68 | 162 | 0 | 291 | 291 |
| 11:37 | 0 | 184 | 1640 | 220 | 0 | 4 | 274 | 1824 | 498 | 2322 |
| 12:09 | 0 | 0 | 7 | 0 | 14 | 81 | 571 | 7 | 666 | 673 |
| 12:41 | 0 | 0 | 0 | 0 | 0 | 17 | 467 | 0 | 484 | 484 |
| 13:13 | 0 | 0 | 0 | 8 | 4 | 30 | 274 | 0 | 316 | 316 |
| 13:45 | 0 | 12 | 20 | 0 | 43 | 0 | 71 | 32 | 114 | 146 |
| 14:17 | 8051 | 3198 | 1181 | 436 | 827 | 467 | 539 | 12430 | 2269 | 14699 |
| 14:49 | 0 | 0 | 0 | 110 | 137 | 43 | 165 | 0 | 455 | 455 |
| 15:21 | 0 | 12 | 0 | 12 | 244 | 561 | 868 | 12 | 1685 | 1697 |
| 15:53 | 0 | 12 | 7 | 8 | 7 | 15 | 85 | 19 | 115 | 134 |
| 16:25 | 0 | 159 | 0 | 0 | 237 | 704 | 377 | 159 | 1318 | 1477 |
| 16:57 | 0 | 25 | 72 | 16 | 40 | 36 | 131 | 97 | 223 | 320 |
| 17:29 | 61 | 25 | 0 | 265 | 927 | 66 | 245 | 86 | 1503 | 1589 |
| 18:01 | 0 | 37 | 13 | 0 | 75 | 288 | 677 | 50 | 1040 | 1090 |
| 18:33 | 2218 | 1213 | 1194 | 1499 | 2322 | 1199 | 521 | 4625 | 5541 | 10166 |
| 19:04 | 0 | 0 | 0 | 0 | 18 | 13 | 61 | 0 | 92 | 92 |
| 19:36 | 0 | 12 | 125 | 12 | 0 | 11 | 45 | 137 | 68 | 205 |
| 21:36 | 213 | 159 | 125 | 77 | 122 | 100 | 128 | 497 | 427 | 924 |
| 22;08 | 122 | 147 | 111 | 122 | 165 | 90 | 101 | 380 | 478 | 858 |
| 22:40 | 486 | 466 | 105 | 196 | 176 | 216 | 224 | 1057 | 812 | 1869 |
| 23:12 | 486 | 257 | 72 | 57 | 104 | 105 | 322 | 815 | 588 | 1403 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 23:44 | 213 | 135 | 118 | 212 | 183 | 137 | 311 | 466 | 843 | 1309 |
| 00:16 | 243 | 86 | 118 | 147 | 370 | 8962 | 273 | 447 | 9752 | 10199 |
| 00:48 | 0 | 49 | 105 | 29 | 115 | 87 | 233 | 154 | 464 | 618 |
| 01:28 | 91 | 37 | 33 | 69 | 90 | 92 | 173 | 161 | 424 | 585 |
| 01:51 | 61 | 49 | 98 | 57 | 111 | 119 | 306 | 208 | 593 | 801 |
| 02:23 | 365 | 245 | 92 | 94 | 101 | 218 | 303 | 702 | 716 | 1418 |
| 03:23 | 152 | 282 | 59 | 126 | 320 | 905 | 393 | 493 | 1744 | 2237 |
| 03:55 | 365 | 184 | 374 | 90 | 137 | 237 | 244 | 923 | 708 | 1631 |
| 04:27 | 608 | 86 | 164 | 49 | 40 | 237 | 250 | 858 | 576 | 1434 |
| 04:59 | 152 | 98 | 85 | 41 | 147 | 230 | 301 | 335 | 719 | 1054 |
| 05:31 | 0 | 0 | 0 | 53 | 528 | 717 | 508 | 0 | 1806 | 1806 |
| 06:03 | 273 | 0 | 0 | 228 | 492 | 333 | 866 | 273 | 1919 | 2192 |
| 06:35 | 0 | 0 | 0 | 0 | 7 | 294 | 388 | 0 | 689 | 689 |
| 07:07 | 0 | 0 | 7 | 86 | 457 | 461 | 350 | 7 | 1354 | 1361 |
| 07:39 | 0 | 37 | 0 | 8 | 4 | 216 | 236 | 37 | 464 | 501 |
| 08:11 | 0 | 0 | 0 | 73 | 50 | 314 | 340 | 0 | 777 | 777 |
| 08:43 | 0 | 0 | 20 | 0 | 7 | 252 | 454 | 20 | 713 | 733 |
| 09:14 | 0 | 0 | 0 | 147 | 47 | 85 | 244 | 0 | 523 | 523 |
| 09:46 | 0 | 0 | 0 | 20 | 7 | 19 | 106 | 0 | 152 | 152 |
| 10:18 | 0 | 0 | 98 | 232 | 11 | 262 | 394 | 98 | 899 | 997 |
| 10:50 | 0 | 0 | 0 | 0 | 0 | 190 | 273 | 0 | 463 | 463 |
| 11:21 | 91 | 0 | 794 | 232 | 22 | 354 | 281 | 885 | 889 | 1774 |
| 12:01 | 61 | 0 | 0 | 0 | 4 | 376 | 483 | 61 | 863 | 924 |
| 12:33 | 0 | 0 | 7 | 0 | 4 | 446 | 377 | 7 | 827 | 834 |
| 13:05 | 0 | 0 | 0 | 37 | 32 | 444 | 427 | 0 | 940 | 940 |
| 13:37 | 0 | 0 | 0 | 359 | 219 | 403 | 346 | 0 | 1327 | 1327 |
| 14:25 | 0 | 0 | 0 | 12 | 248 | 593 | 816 | 0 | 1669 | 1669 |
| 14:57 | 0 | 0 | 0 | 0 | 633 | 770 | 673 | 0 | 2076 | 2076 |
| 15:29 | 0 | 0 | 0 | 8 | 101 | 380 | 459 | 0 | 948 | 948 |
| 16:01 | 0 | 0 | 7 | 4 | 4 | 149 | 154 | 7 | 311 | 318 |
| 16:33 | 0 | 0 | 0 | 0 | 0 | 4 | 180 | 0 | 184 | 184 |
| 17:15 | 0 | 0 | 0 | 0 | 4 | 23 | 109 | 0 | 136 | 136 |
| 17:47 | 0 | 0 | 0 | 0 | 29 | 34 | 165 | 0 | 228 | 228 |
| 18:18 | 0 | 12 | 33 | 587 | 1470 | 542 | 377 | 45 | 2976 | 3021 |
| 18:50 | 0 | 0 | 0 | 57 | 421 | 743 | 728 | 0 | 1949 | 1949 |

n ====> 77

| | 6-21m | 21-40m | 6-40m |
|---|---|---|---|
| Mean: | 398.96 | 839.62 | 1238.58 |
| Std.Dev.: | 1504.27 | 1312.25 | 2249.07 |

[JULY] ADJUSTED COUNTS (Transducer #4)

| TIME | 6-11m | 11-16m | 16-21m | 21-26m | 26-30m | 30-35m | 35-40m | 6-26m | 26-40m | 6-40m |
|---|---|---|---|---|---|---|---|---|---|---|
| 22:12 | 61 | 0 | 20 | 0 | 0 | 145 | 38 | 81 | 183 | 264 |
| 22:44 | 0 | 12 | 0 | 0 | 0 | 45 | 29 | 12 | 74 | 86 |
| 23:16 | 0 | 25 | 13 | 4 | 7 | 90 | 27 | 42 | 124 | 166 |
| 23:48 | 0 | 0 | 0 | 0 | 11 | 70 | 6 | 0 | 87 | 87 |
| 00:20 | 0 | 0 | 7 | 0 | 0 | 128 | 8 | 7 | 136 | 143 |
| 00:52 | 0 | 0 | 0 | 16 | 7 | 19 | 6 | 16 | 32 | 48 |
| 01:24 | 61 | 61 | 7 | 0 | 7 | 113 | 27 | 129 | 147 | 276 |
| 01:56 | 30 | 12 | 7 | 4 | 40 | 158 | 67 | 53 | 265 | 318 |
| 02:28 | 30 | 49 | 262 | 29 | 58 | 177 | 24 | 370 | 259 | 629 |
| 03:00 | 304 | 821 | 118 | 53 | 36 | 196 | 63 | 1296 | 295 | 1591 |
| 03:32 | 486 | 270 | 184 | 289 | 676 | 205 | 146 | 1229 | 1027 | 2256 |
| 04:04 | 91 | 233 | 26 | 216 | 144 | 70 | 61 | 566 | 275 | 841 |
| 05:38 | 0 | 25 | 0 | 12 | 4 | 198 | 2 | 37 | 204 | 241 |
| 06:11 | 0 | 12 | 26 | 0 | 0 | 262 | 0 | 38 | 262 | 300 |
| 06:43 | 0 | 0 | 0 | 69 | 0 | 41 | 2 | 69 | 43 | 112 |
| 07:16 | 0 | 0 | 0 | 4 | 0 | 224 | 8 | 4 | 232 | 236 |
| 08:12 | 0 | 0 | 0 | 4 | 0 | 188 | 3 | 4 | 191 | 195 |
| 09:06 | 0 | 0 | 0 | 8 | 0 | 158 | 2 | 8 | 160 | 168 |
| 09:38 | 0 | 0 | 0 | 122 | 0 | 339 | 13 | 122 | 352 | 474 |
| 10:10 | 6836 | 2683 | 275 | 0 | 79 | 563 | 298 | 9794 | 940 | 10734 |
| 10:41 | 0 | 12 | 0 | 0 | 0 | 205 | 50 | 12 | 255 | 267 |
| 11:13 | 7140 | 0 | 0 | 0 | 0 | 254 | 204 | 7140 | 458 | 7598 |
| 11:45 | 6836 | 1311 | 0 | 0 | 0 | 164 | 64 | 8147 | 228 | 8375 |
| 12:17 | 12456 | 404 | 0 | 0 | 0 | 188 | 156 | 12860 | 344 | 13204 |
| 12:49 | 1367 | 0 | 39 | 0 | 0 | 201 | 369 | 1406 | 570 | 1976 |
| 13:21 | 2430 | 25 | 1023 | 253 | 0 | 209 | 90 | 3731 | 299 | 4030 |
| 13:53 | 0 | 25 | 0 | 0 | 0 | 175 | 6 | 25 | 181 | 206 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 14:25 | 2279 | 61 | 0 | 0 | 0 | 28 | 32 | 2340 | 60 | 2400 |
| 14:57 | 6562 | 0 | 33 | 0 | 32 | 414 | 776 | 6595 | 1222 | 7817 |
| 15:29 | 14006 | 8625 | 5844 | 1316 | 0 | 265 | 409 | 29791 | 674 | 30465 |
| 16:01 | 15008 | 6554 | 1961 | 69 | 32 | 162 | 119 | 23592 | 313 | 23905 |
| 16:33 | 4831 | 3038 | 1213 | 228 | 25 | 149 | 175 | 9310 | 349 | 9659 |
| 17:05 | 7231 | 5697 | 2217 | 521 | 93 | 113 | 188 | 15666 | 394 | 16060 |
| 17:37 | 24366 | 8453 | 1292 | 676 | 1118 | 708 | 385 | 34787 | 2211 | 36998 |
| 18:41 | 243 | 453 | 144 | 114 | 65 | 141 | 149 | 954 | 355 | 1309 |
| 19:12 | 3524 | 1017 | 0 | 0 | 169 | 218 | 38 | 4541 | 425 | 4966 |
| 19:44 | 911 | 1507 | 1174 | 843 | 762 | 785 | 726 | 4435 | 2273 | 6708 |
| 21:44 | 2370 | 1225 | 446 | 367 | 280 | 245 | 117 | 4408 | 642 | 5050 |
| 22:16 | 1519 | 1127 | 571 | 379 | 306 | 205 | 196 | 3596 | 707 | 4303 |
| 22:48 | 942 | 502 | 262 | 167 | 212 | 198 | 88 | 1873 | 498 | 2371 |
| 23:20 | 1701 | 649 | 236 | 281 | 230 | 173 | 157 | 2867 | 560 | 3427 |
| 23:52 | 61 | 172 | 52 | 94 | 65 | 122 | 72 | 379 | 259 | 638 |
| 00:24 | 91 | 147 | 111 | 122 | 187 | 111 | 95 | 471 | 393 | 864 |
| 00:56 | 0 | 159 | 111 | 81 | 32 | 70 | 66 | 351 | 168 | 519 |
| 01:28 | 61 | 37 | 66 | 73 | 129 | 77 | 63 | 237 | 269 | 506 |
| 01:59 | 0 | 221 | 236 | 94 | 252 | 126 | 172 | 551 | 550 | 1101 |
| 02:31 | 1398 | 809 | 367 | 196 | 309 | 194 | 273 | 2770 | 776 | 3546 |
| 03:31 | 2977 | 613 | 525 | 261 | 600 | 320 | 311 | 4376 | 1231 | 5607 |
| 04:03 | 213 | 135 | 236 | 167 | 83 | 431 | 140 | 751 | 654 | 1405 |
| 04:35 | 152 | 233 | 197 | 179 | 122 | 290 | 178 | 761 | 590 | 1351 |
| 05:07 | 0 | 25 | 26 | 57 | 101 | 356 | 125 | 108 | 582 | 690 |
| 05:39 | 0 | 0 | 0 | 0 | 0 | 252 | 3 | 0 | 255 | 255 |
| 06:11 | 0 | 0 | 0 | 0 | 7 | 248 | 0 | 0 | 255 | 255 |
| 06:43 | 0 | 0 | 0 | 0 | 0 | 273 | 0 | 0 | 273 | 273 |
| 07:15 | 0 | 0 | 0 | 0 | 0 | 309 | 21 | 0 | 330 | 330 |
| 07:47 | 0 | 0 | 0 | 20 | 4 | 318 | 13 | 20 | 335 | 355 |
| 08:19 | 0 | 0 | 0 | 0 | 0 | 169 | 14 | 0 | 183 | 183 |
| 08:51 | 0 | 0 | 0 | 12 | 0 | 130 | 0 | 12 | 130 | 142 |
| 09:22 | 0 | 0 | 0 | 0 | 0 | 115 | 14 | 0 | 129 | 129 |
| 09:54 | 0 | 0 | 0 | 0 | 43 | 186 | 42 | 0 | 271 | 271 |
| 10:26 | 0 | 0 | 0 | 20 | 7 | 156 | 109 | 20 | 272 | 292 |
| 10:58 | 0 | 0 | 0 | 29 | 4 | 145 | 14 | 29 | 163 | 192 |
| 11:29 | 0 | 0 | 0 | 20 | 0 | 92 | 0 | 20 | 92 | 112 |
| 12:09 | 0 | 0 | 0 | 29 | 4 | 446 | 0 | 29 | 450 | 479 |
| 12:41 | 0 | 0 | 0 | 41 | 101 | 440 | 38 | 41 | 579 | 620 |
| 13:13 | 0 | 0 | 0 | 0 | 0 | 390 | 6 | 0 | 396 | 396 |
| 13:45 | 516 | 502 | 413 | 98 | 4 | 373 | 2 | 1529 | 379 | 1908 |
| 14:33 | 0 | 0 | 0 | 0 | 0 | 198 | 26 | 0 | 224 | 224 |
| 15:05 | 0 | 0 | 72 | 20 | 97 | 395 | 50 | 92 | 542 | 634 |
| 15:37 | 0 | 0 | 0 | 0 | 0 | 373 | 0 | 0 | 373 | 373 |
| 16:09 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 13 | 13 |
| 17:23 | 0 | 0 | 0 | 0 | 0 | 11 | 59 | 0 | 70 | 70 |
| 17:55 | 91 | 123 | 39 | 29 | 7 | 0 | 11 | 282 | 18 | 300 |
| 18:26 | 0 | 159 | 0 | 0 | 0 | 143 | 3 | 159 | 146 | 305 |
| 18:58 | 2947 | 2377 | 643 | 342 | 79 | 122 | 24 | 6309 | 225 | 6534 |

| n ====> 76 | 6-26m | 26-40m | 6-40m |
|---|---|---|---|
| Mean: | 2816.67 | 398.41 | 3215.08 |
| Std.Dev.: | 6319.17 | 396.19 | 6522.80 |

Transducers #1 and #3

| n ====> 152 | 6-21m | 21-40m | 6-40m |
|---|---|---|---|
| Mean: | 530.61 | 1390.66 | 1921.28 |
| Std.Dev.: | 1650.48 | 2696.59 | 3375.06 |

Transducers #2 and #4

| n ====> 149 | 6-26m | 6-26m | 6-40m |
|---|---|---|---|
| Mean: | 2840.37 | 320.40 | 3160.77 |
| Std.Dev.: | 6065.61 | 380.28 | 6162.58 |

## APPENDIX C

**Abundance of Fish (Principally Alewife)
AS Determined Using 3.8 cm Mesh Gill**

| | WEST | | EAST | |
|---|---|---|---|---|
| Transducer | 1 | 3 | 2 | 4 |
| June 12-13 | 52 | 35 | 24 | 49 |
| June 13-14 | 20 | 42 | 45 | 51 |
| July 24-25 | 25 | 29 | 47 | 329 |
| July 25-26 | 59 | 34 | 266 | 486 |
| October 16-17 | 4 | 2 | 4 | 3 |